Estimating Benefits and Costs of Improvement Strategies for the California I/M Program: Implementation Options for Using RSD

REPORT
VERSION 7

For peer review and public comment

Prepared for:

California Air Resources Board and California Bureau of Automotive Repair

Prepared by:

Eastern Research Group, Inc.

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Glossary

Call-In ASM – A mid-cycle ASM test performed to determine if a vehicle needs to be repaired before its next regular I/M test.

Calling-In No-Sticker – An I/M program improvement strategy in which high-risk vehicles are requested mid-cycle to get an ASM test. Vehicles are not given a new 24-month certification for meeting call-in ASM requirements. In this instance, vehicles must follow the reinspection requirements of their existing certification even though they have participated in the call-in process.

Calling-In Sticker – An I/M program improvement strategy in which high-risk vehicles are requested mid-cycle to get an ASM test. In this instance, vehicles that meet call-in requirements are issued a new 24-month certification at the time of the call-in ASM. The vehicles are, therefore, on a new reinspection schedule and would be expected to receive their next-cycle inspection in about 24 months after the call-in ASM.

CN – Calling-In No-Sticker

CS – Calling-In Sticker

Cprob – The cumulative I/M completion probabilities. The probability that a vehicle will receive its next-cycle certification within a given number of months after its previous-cycle certification.

Decision Point – The date when a decision is made to intervene in the Normal I/M Process or not.

DI – Directing

Directing – An I/M program improvement strategy in which vehicles that are expected to soon appear for their biennial inspection are sent to high-performing stations instead of allowing the vehicle owner to choose the inspection station. In general, high-risk vehicles are directed.

EX – Exempting

Exempting – An I/M program improvement strategy in which vehicles that are expected to soon appear for their biennial inspection are allowed to skip the inspection and receive a standard 24-month certification. In general, low-risk vehicles are exempted.

FMD – Failed Miles Driven. An acronym to describe miles driven in an ASM-failed status over the 24 months following a decision point. The value is calculated by summing the monthly estimate of overall ASM failure probability times the number of miles driven in the month. It is a probabilistic value because the ASM failure probability is an estimate of the fraction of vehicles with the same vehicle description, VID history, and/or RSD measurements that would fail an ASM test.

ΔFMD – Change in failed miles driven over the 24 months following the decision point. ΔFMD is a measure of the change in failed miles driven caused by a selected intervention. A negative ΔFMD indicates that the intervention caused the failed miles driven to drop in comparison with the Normal I/M Process.

Fprob – The probability that a vehicle will fail a test. Fprob is also equivalent to the fraction of vehicles that would fail the test for those vehicles in the same circumstance. All Fprobs in this study are fractions.

ΔFTP/$ – The change in FTP mass emissions over the 24 months after a Scrapping decision in comparison with the Normal I/M Process divided by the market value of the vehicle.

Intervention – The act of taking special action that is beyond the Normal I/M Process. Examples of intervention include sending letters to I/M program participants for Directing, Exempting, Calling-In, or Scrapping.

NIM – Normal I/M Process

Normal I/M Process – The process by which vehicles that participate in the California I/M program voluntarily get their vehicles inspected at I/M program stations in accordance with the rules for 24-month certifications. The Normal I/M Process includes biennial inspections and change of ownership inspections. The Normal I/M Process does not include, for discussion purposes in this study, Directing, Exempting, Calling-In, or Scrapping.

NX – One or more of the oxides of nitrogen. Although NO and NOx are measured differently and are different chemically, we make no distinction here.

RSD – Remote Sensing Device. An instrument that measures the instantaneous tailpipe emissions concentrations of HC, CO, and NX of on-road vehicles by shining a light beam across the road so that it intercepts the plume from the vehicle's tailpipe.

Scrappage ASM – A mid-cycle ASM test performed to determine if the State should purchase the vehicle to retire it.

Scrapping – An I/M program improvement strategy in which high-risk vehicles are purchased from their owners by the State and destroyed. High-priority Scrapping candidates are those that produce a large mass of emissions and have a low market value.

SP – Scrapping

VID – An I/M program's vehicle information database, which contains a specified list of variables that characterize all past inspections of vehicles participating in the I/M program.

VID History – The entire list of records from the VID for an individual vehicle that describes all of the interactions between the vehicle and the I/M program throughout the period during which the vehicle was participating in the I/M program.

VSP – Vehicle specific power. A measure of the instantaneous power required per unit of vehicle mass required to move the vehicle at a given instant. The units of VSP in this study are kilowatts/megagram (kW/Mg).

1.0 Introduction

This report estimates the incremental benefits and costs of adding remote sensing device (RSD) measurement capabilities to the existing California I/M Program. RSD is a technology that measures the emissions of vehicles as they pass the RSD instruments on the side of the roadway. This report will use estimated costs of RSD implementation and estimated benefits to evaluate different implementation strategies. The benefits of adding RSD to the I/M program are determined by an evaluation of the estimated fleet benefits when vehicles are ranked by variables that include RSD information (which requires on-road data collection) and by variables that include data already collected by the I/M program (VID History), but do not include RSD information.

In the modeling report [1], we described how the RSD evaluation was developed. In this implementation report we will describe specific strategies that could use RSD and other techniques to enhance the I/M program. The modeling report described the benefits for the sampled fleet of 69,629 vehicles. In this report we project the costs and benefits to the 2004 California fleet. Costs and benefits are calculated for a mix of strategies to examine the incremental impact of RSD technology.

It should be noted that RSD and other strategies can be used in many different ways. We have tried to select the most appropriate uses of the RSD technology and present the costs and benefits of these in this report.

2.0 Intervention Activities Evaluated in This Report

The analysis in this document specifically addresses the first four questions from Task 1 of the work assignment. *The primary objective of this study is to assess the effectiveness of remote sensing technology as a supplemental tool to enhance California's inspection and maintenance program. Specifically, the pilot study shall determine:*

a. Whether remote sensing technology can be used to improve the state's high emitter profile (HEP), used to direct vehicles to high-performing stations.

In this study this intervention activity is called Directing. Directing occurs for vehicles that are expected to soon receive their biennial inspection. For Directing, the vehicles that represent the greatest risk to the state would be required to be inspected at high-performing stations in the I/M program. Directing is already being performed in the I/M program as an intervention activity and is based on gross polluter assignments or the current HEP. The notion of Directing is based on the premise that high-performing stations are less prone to inaccuracies than average-performing stations are.

The benefit of directing vehicles to high-performing stations depends on the difference in performance between high-performing and average-performing stations. In this report we have assumed that average-performing stations, in general, are 80% as effective as high-performing stations. This is an assumption based on previous work by BAR but can be modified in our analysis if new estimates become available. We apply this assumption as an adjustment to the base benefit calculations made in the modeling report. If average-performing stations are just as likely to perform a proper ASM inspection, then the net benefit of Directing is zero. Nevertheless, Directing is a measure that can be applied to the riskiest, or most high emissions potential vehicles. Directing vehicles may cause a higher level of customer inconvenience since they are required to have their vehicles tested at specified stations. If we use a method that finds the vehicles that have the largest future increase in failed miles driven, then the riskiest vehicles have a better chance of being properly inspected while causing only small increases in customer inconvenience.

b. Whether remote sensing technology can be an effective tool to "clean screen" vehicles and exempt them from the next scheduled smog check inspection thus reducing program costs.

We have performed benefits calculations for this intervention activity which we call Exempting. Exempting would normally occur shortly before vehicles are expected to appear for their biennial inspection. Vehicles that are expected to be of low risk to the I/M program would be ranked higher on an Exempting list. Vehicles that are exempted would be given a certification without coming in for a regular I/M test. Exempted vehicles would be expected to appear two years later for their next biennial inspection in accordance with their new certification unless they were exempted again. Exempting is expected to always increase emissions and failed miles driven. The goal of the vehicle prioritization is to preferentially exempt vehicles that would have the smallest increases, which would represent the smallest risk to the airshed.

For Exempting we want to identify vehicles that would drive the smallest number of miles in a failed status over the 24 months after the Exempting decision. The Exempting decision is made in the month that vehicles are scheduled to receive their next inspection. When vehicles are exempted, they receive a new certification sticker but are not required to get an ASM emissions test. Accordingly, all exempted vehicles as a group – even those that would pass – continue on their average trend of ever increasing emissions. In addition, vehicles that would fail are mistakenly not inspected and therefore not repaired. For both reasons, Exempting causes the failed miles driven and the FTP emissions over the next 24 months to be higher than if Exempting were not practiced. Nevertheless, if we can use a method that finds the vehicles that have the lowest future increases in these two quantities, then the increases can be minimized while achieving large increases in customer convenience.

c. *Whether remote sensing technology can be an effective tool to identify high-emitting vehicles between regular inspection cycles and to document the emission reduction benefits of such a program.*

In the analysis in this report, we call this intervention activity Calling-In, in which vehicles are considered for Calling-In at anytime in the I/M program cycle. We performed benefit calculations for one Calling-In option called Calling-In No-Sticker where vehicles would be given an I/M station ASM test and if they failed the test the vehicle would be required to be repaired and to pass a follow up ASM test. However, for this effort the vehicle would not be given an emissions certification but would be required to continue on its existing regular I/M program schedule. The other policy option, which was not used in this analysis, is called Calling-In Sticker. In this case, the vehicle would also be called in for an intervention test performed at a regular I/M station and would be required to be repaired and to pass a follow-up ASM test. However, the vehicle would then be issued a new biennial certification. This would put the vehicle on a new regular I/M schedule.

d. Whether remote sensing technology can be an effective tool to identify vehicles that would be, based on the vehicle emission levels (and overall condition), candidates for early retirement (scrappage).

In this document we call this intervention activity Scrapping. In this analysis, we consider Scrapping for vehicles at any point in their I/M program cycle. For these calculations, scrappage candidate vehicles would be called-in for a scrappage ASM test that would be performed at a regular I/M station. If the vehicle failed the test, the state would offer to purchase the vehicle from the owner for scrappage. If the vehicle passed the scrappage ASM test, the vehicle would be released without issuing a new certification. Scrappage candidates would be selected from the fleet based on their estimated decrease in FTP emissions over 24 months per dollar of vehicle value. By using this ranking variable, the state will come close to maximizing the total mass of emissions that are reduced through the purchase and scrapping of the candidate vehicles.

The estimation of benefits for scrapping differs somewhat from that of Directing, Exempting, and Calling-In. Vehicle rankings and the selection of the top candidates from the rankings are different because when a vehicle is scrapped all of the emissions of the vehicle – not just the excess emissions – drop to zero.[1]

The essence of Scrapping is that the mass emissions to be emitted during the vehicle's remaining life are "purchased" by the State. If we assume that California's annual scrappage budget is $8,000,000, we want to rank vehicles for scrapping such that the vehicles that constitute the best "bargains" are at the top of the list. Accordingly, to estimate how good a bargain a vehicle is, for each vehicle we divide the benefits to be realized by scrapping the vehicle by the estimated value of the vehicle. Each scrappage ranking is then used by "purchasing" vehicles from the top of the ranking until the $8,000,000 is spent. Depending on the values of the vehicles at the top of each ranking, different numbers of vehicles may be purchased for different rankings. The mass

[1] For the purposes of ranking vehicles, we do not need to consider the emissions of the owner's replacement vehicle. For evaluating the emissions benefits of Scrapping, by assuming that the replacement vehicle has zero emissions, we are calculating the maximum emissions benefits that could be achieved by a Scrapping program.

emissions over the remaining life of the purchased vehicles is the mass emissions bought with the $8,000,000.

2.1 Basic Ranking Methods

In the modeling report [1], we developed 35 methods that can be used to rank vehicles for various intervention strategies. Table 2-1, which is taken from that report, summarizes the 35 ranking methods (Column 2) in terms of the basic ranking criterion (Column 1), the type of data required (Column 3), and the strategies that each can be applied to (Column 4) as shown by an X or a large dot. For the cost-benefit analysis described in this report we have chosen five basic sets of ranking method inputs to evaluate: A (Model Year), B (Vehicle Description), C (VID History), D (VID History + RSD), and F (RSD). Three of the sets of inputs do not use RSD and two do. Based on the evaluations performed in the modeling report, for further investigation in this report, we selected only the best performing methods for the strategies and for each of the five sets of ranking method inputs. Under each strategy heading in the last column of Table 2-1, the chosen vehicle ranking methods are shown by a large dot.

Model Year Inputs – FprobDP by A (Method 18) ranks vehicles for selection for Directing, Exempting, and Calling-In No-Sticker by a vehicle’s overall ASM failure probability at the Decision Point. This one-point-in-time probability takes into account only the model year of the vehicle. This method does not distinguish among rankings for different types of interventions. For Scrapping, the corresponding ranking method of choice is FprobDP/$ by A (Method 24) since we know from the modeling report that using vehicle value in the denominator greatly improves Scrapping ranking performance.

Vehicle Description Inputs – FprobDP by B (Method 19) ranks vehicles for selection for Directing, Exempting, and Calling-In No-Sticker by a vehicle’s overall ASM failure probability at the Decision Point. This one-point-in-time probability takes into account only the vehicle description, which is made up of model year, make, car or truck, engine, and emission control system. This method does not distinguish among different types of interventions. For Scrapping, the corresponding ranking method of choice is FprobDP/$ by B (Method 25).

RSD Inputs – FprobDP by F (Method 23) ranks vehicles for selection for Directing, Exempting, and Calling-In No-Sticker by a vehicle’s overall ASM failure probability at the Decision Point. This one-point-in-time probability takes into account only the vehicle’s recent RSD HC, CO, and NX measurements. This method does not distinguish among different types of interventions. For Scrapping, the corresponding ranking method of choice is FprobDP/$ by F (Method 29).

Table 2-1. Categorization of the 35 Ranking Methods

Description of Vehicle Ranking Criterion		Vehicle Ranking Method	Model On Which the Vehicle Ranking is Based (Type of Data Required)	Strategy That Ranking Method Can Be Used For				
				DI	EX	CN	CS	SP
Change in Failed Miles Driven Over 24 Months after the Decision Point (ΔFMD)	1	DI ΔFMD by C	C (VID History)	●				
	2	EX ΔFMD by C	C (VID History)		●			
	3	CN ΔFMD by C	C (VID History)			●		
	4	CS ΔFMD by C	C (VID History)				X	
	5	DI ΔFMD by D	D (VID History + RSD)	●				
	6	EX ΔFMD by D	D (VID History + RSD)		●			
	7	CN ΔFMD by D	D (VID History + RSD)			●		
	8	CS ΔFMD by D	D (VID History + RSD)				X	
Change in FTP Mass Emissions Over 24 Months after the Decision Point per Vehicle Value Dollar (ΔFTP/$)	9	ΔFTP HC/$ by C	C (VID History)					X
	10	ΔFTP CO/$ by C	C (VID History)					●
	11	ΔFTP NX/$ by C	C (VID History)					X
	12	ΔFTP HC/$ by D	D (VID History + RSD)					X
	13	ΔFTP CO/$ by D	D (VID History + RSD)					●
	14	ΔFTP NX/$ by D	D (VID History + RSD)					X
	15	ΔFTP HC/$ by E	E (ASM Cutpoints + RSD)					X
	16	ΔFTP CO/$ by E	E (ASM Cutpoints + RSD)					X
	17	ΔFTP NX/$ by E	E (ASM Cutpoints + RSD)					X
Fprob at Decision Point (FprobDP)	18	FprobDP by A	A (Model Year)	●	●	●	X	X
	19	FprobDP by B	B (Vehicle Description)	●	●	●	X	X
	20	FprobDP by C	C (VID History)	X	X	X	X	X
	21	FprobDP by D	D (VID History + RSD)	X	X	X	X	X
	22	FprobDP by E	E (ASM Cutpoints + RSD)	X	X	X	X	X
	23	FprobDP by F	F (RSD)	●	●	●	X	X
Fprob at Decision Point per Vehicle Value Dollar (FprobDP/$)	24	FprobDP/$ by A	A (Model Year)					●
	25	FprobDP/$ by B	B (Vehicle Description)					●
	26	FprobDP/$ by C	C (VID History)					X
	27	FprobDP/$ by D	D (VID History + RSD)					X
	28	FprobDP/$ by E	E (ASM Cutpoints + RSD)					X
	29	FprobDP/$ by F	F (RSD)					●
One-Time Observed RSD Emissions Concentration	30	RSD [HC]	No Model (Measured [RSD])	X	X	X	X	X
	31	RSD [CO]	No Model (Measured [RSD])	X	X	X	X	X
	32	RSD [NX]	No Model (Measured [RSD])	X	X	X	X	X
One-Time Observed RSD Emissions Concentration per Vehicle Value Dollar	33	RSD [HC]/$	No Model (Measured [RSD])					X
	34	RSD [CO]/$	No Model (Measured [RSD])					X
	35	RSD [NX]/$	No Model (Measured [RSD])					X

DI = Directing
CS = Calling-In Sticker
EX = Exempting
SP = Scrapping
CN = Calling-In No-Sticker

VID History Inputs – ΔFMD by C ranks vehicles for selection by the Model-C-estimated change in the estimated number of miles the vehicle will drive in an ASM-failed status over the 24 months after the Decision Point if the vehicle participated in the strategy. Model C is our best non-RSD method. This integrated estimate of risk to the I/M program takes into account the ASM cutpoints, vehicle age, previous-cycle initial-ASM-test pass/fail result, time since the previous-cycle initial test, as well as the vehicle description, which is made up of model year, make, car or truck, engine, and emission control system. This method also takes into account the details of different types of interventions and can create rankings that distinguish among them. Accordingly, the VID history ranking method for Directing is DI ΔFMD by C (Method 1), for Exempting is EX ΔFMD by C (Method 2), and for Calling-In No-Sticker is CN ΔFMD by C (Method 3). For Scrapping, the VID history ranking method of choice is ΔFTP CO/$ by C (Method 10) since FTP mass emissions is the focus of Scrapping.

RSD/VID Inputs – ΔFMD by D also ranks vehicles for selection by the Model-D-estimated change in the number of miles the vehicle will drive in an ASM-failed status over the 24 months after the Decision Point if the vehicle participated in the strategy. Model D is our best method that includes RSD measurements. This integrated estimate of risk to the I/M program takes into account a vehicle's recent RSD HC, CO, and NX, as well as the ASM cutpoints, vehicle age, previous-cycle initial-ASM-test pass/fail result, time since the previous-cycle initial test, and the vehicle description, which is made up of model year, make, car or truck, engine, and emission control system. This method also takes into account the details of different types of interventions and can create rankings that distinguish among them. Accordingly, the RSD/VID ranking method for Directing is DI ΔFMD by D (Method 5), for Exempting is EX ΔFMD by D (Method 6), and for Calling-In No-Sticker is CN ΔFMD by D (Method 7). For Scrapping, the VID history ranking method of choice is ΔFTP CO/$ by D (Method 13) since FTP mass emissions is the focus of Scrapping.

2.2 Measures of Benefits and Other Practical Quantities

For each fleet ranking method, we need to calculate quantities that can be used to judge the value of adding intervention activities to the I/M program. Value is ultimately determined by considering costs and benefits; however, other quantities of a practical nature can also be used to evaluate. In this cost-benefit analysis, we consider three quantities. The first two are benefits:

- Change in failed miles driven (FMD) of the I/M fleet over the 24 months after each vehicle's decision point.

- Change in FTP HC, CO, and NX mass emissions of the I/M fleet over the 24 months after the decision point.

And the third is not an actual benefit, but is a quantity of practical importance:

- Fraction of vehicles that fail the ASM test at the decision point.

2.3 Existing I/M Program Benefits and Annual I/M Program Benefits

At the conclusion of this report, we will estimate the biennial mass emissions benefits of individual I/M program intervention activities. To put those results in perspective, we provide biennial estimates of the total I/M benefit (that is, relative to no I/M program) and the incremental biennial benefit of an annual I/M program over a biennial I/M program.

For comparison purposes the current program has been estimated to reduce HC, CO and NX emissions by the following amounts in Calendar Year 2004 based on "Evaluation of the California Enhanced Vehicle Inspections and Maintenance (Smog Check) Program," April 2004 Draft Report to the Inspection and Maintenance Review Committee:

- Exhaust HC – 127 tons/day (92,710 tons/2 years)
- CO – 1360 tons/day (992,800 tons/2 years)
- NX – 158 tons/day (115,340 tons/2 years)

ERG also estimated the benefit if the current program were converted to an annual program rather than the existing biennial program, all other aspects being equal. We estimated this change using the latest version of the EMFAC 2.20.8 version for Calendar Year 2004. The estimated additional benefit would be:

- Exhaust HC – 28 tons/day (20,577 tons/2 years)
- CO – 378 tons/day (275,683 tons/2 years)
- NX – 44 tons/day (32,359 tons/2 years)

Thus, the incremental HC plus NX benefit from an annual program over a biennial program is estimated by EMFAC to be 52,936 tons/2years. As we shall see in Section 6, the size of the HC plus NX emissions benefits of a package of supplemental I/M program strategies made up of Calling-In, Directing, Exempting, and Scrapping operating under expected fleet vehicle targeting criteria in the five largest AQMDs is on the order of 10,000 tons/2years. This value is relatively independent of whether RSD is used or not.

3.0 Conditions for Calculating Cost-Effectiveness

The cost-effectiveness calculations presented in this report are specific to a particular example scenario that we chose to demonstrate the results for special strategies that could supplement the I/M program. This scenario is described in Section 3.1. The ability of an RSD measurement program to cover the I/M fleet is key to RSD's usefulness as a supplementary component to the I/M program. RSD coverage is discussed in Section 3.2.

The cost and benefits calculated in this analysis are for a two-year time frame, a full I/M fleet basis, and are incremental to the base case. The following describes the rationale for these three choices for the analysis:

- We have chosen a two-year time frame because the I/M program is biennial. The benefits estimated in the modeling report [1] were on a two-year basis, and therefore, we have chosen to bring costs in on the same basis.

- Using a full I/M fleet basis, which is designed to cover all or nearly all, of the vehicles in the I/M fleet, makes understanding the costs and benefits easier. The non-RSD vehicle ranking methods can be applied to almost all fleet vehicles; however, vehicle ranking methods that require RSD measurements can be used on, at most, 20% of the I/M fleet. The reason for this is that even with the largest statewide RSD program, only 20% of the vehicles in the I/M fleet will receive RSD readings that are valid and DMV-matched and are obtained while the vehicle is operating under emissions-representative conditions. Therefore, when evaluating costs and benefits for the full-fleet using ranking methods containing RSD inputs, part of the fleet is ranked with ranking methods that require RSD inputs, and the remainder of the fleet is ranked using non-RSD ranking methods.

- The intent of this evaluation is to determine the cost-effectiveness of adding intervention activities to the I/M program. Therefore, we calculate incremental costs and benefits relative to the I/M program. We are not attempting to estimate the costs and benefits of the I/M program, and we are not attempting to estimate the costs and benefits of a stand-alone RSD program. Because the costs and benefits are incremental, the costs and benefits can be credits or debits relative to the base case I/M program.

3.1 Description of the Example Scenario

The costs, benefits, and cost-effectiveness of supplementing the I/M program with RSD measurements depends on the mix of intervention activities (Calling-In, Directing, Exempting, or Scrapping) that are chosen, on the fleet targeting or penetration chosen for each intervention activity, and on the method chosen to prioritize vehicles for targeting. Since it is not possible to present all possible combinations of these choices in this report, we use one combination that serves as a "test bed" to demonstrate the calculations.

We selected all four intervention activities (Calling-In, Directing, Exempting, and Scrapping) for the mix so that all four types of activities could be costed. In addition, because RSD costs tend to be constant for a given portion of the fleet covered, using the RSD data for as many activities as possible increases the value of the RSD measurement program. Including all four activities, therefore, makes the incremental cost-benefit calculated for adding RSD to the I/M program as attractive as possible. If, under these evaluation conditions, RSD is found to not be cost-effective, RSD is likely to not be cost-effective under less-favorable conditions.

For the example scenario we needed to select one mix of intervention activities with an I/M fleet penetration for each activity. Penetration is the fraction of the I/M fleet that is selected for targeting for a specific type of intervention activity. Targeted vehicles are those whose selection would most benefit the goals of the I/M program. The fleet penetrations were chosen to be realistic, that is, near the levels that we thought would most likely be used in the California I/M program.

The fleet penetrations used in this cost-benefit analysis were 5% for Calling-In No-Sticker, 40% for Directing, 20% for Exempting, and whatever fleet targeting percentage was needed to spend $16,000,000 to purchase scrappage vehicles over one biennial cycle. This resulted in a penetration for Scrapping of approximately 0.24% to 0.62% of the fleet.

The fleet penetration of 40% for Directing was chosen because it was near the 36% penetration that is currently being used in the I/M program for Directing. In the case of Exempting, the evaluation in the modeling report [1] indicated that emissions and failed miles driven "give aways" would be relatively small for Exempting penetrations up to 20% of the fleet. Note that this 20% for Exempting is beyond the policy exemption of the six newest model years that is already in place in the I/M program. Similarly, for Calling-In No-Sticker, the modeling report indicated that the benefits that could be achieved at a 5% penetration were attractive. Since Calling-In vehicles represents an increased load on the I/M program inspection stations, we did not want to evaluate fleet penetrations higher than 5% at this time. The fleet penetrations used for Scrapping were the result of "spending" $16,000,000 over the two-year I/M cycle for the purchase of scrappage vehicles. The fleet penetration percentage for Scrapping varies by the ranking method. This is a result of the different ranking properties of each of the ranking methods.

3.2 Quantifying Fleet RSD Coverage

The size of an RSD data collection effort is driven by the desired coverage of the fleet. RSD cannot get measurements on all vehicles in the on-road fleet. RSD units can be deployed only in locations meeting special criteria such as the number of vehicles passing at a time, space on the side of the road to safely fit the equipment, and the speed and operating mode of passing vehicles. Also, it is not generally cost effective to measure at sites with little traffic. Unmanned RSD units will get around some of these limitations, but they have their own limitations having to do with installing utilities in remote areas. Since a certain fraction of the fleet will seldom pass by some RSD sites, that fraction of the fleet has little chance of getting an RSD measurement.

As vehicles pass by an RSD unit, not all of them receive a valid measurement, not all of those produce a license plate image that is usable, not all of those are vehicles that have not already been measured, and not all of those are being operated in a way that fairly represents the typical emissions of the vehicle. The fractions we use to account for this effect depend upon the size of the program relative to the size of the fleet. For example, it takes much more than five times the effort to get a valid reading on 50% of the fleet than on 10% of the fleet.

Two definitions of RSD fleet coverage – In this analysis, we discuss the coverage of the fleet with RSD measurements using two different definitions of coverage. The reader should understand these two distinct definitions because they affect the calculated costs and benefits of the analysis. Either definition can express RSD coverage relative to either the total number of vehicles in the fleet or the total number of vehicles in the I/M fleet. The important distinction between the two definitions is whether the RSD measurements are taken on a vehicle when it is operating in the emissions-representative VSP range (5 to 25 kW/Mg)[2] or whether it is operating at any VSP. The two definitions are:

- **Any-VSP RSD coverage** – This refers to the number of vehicles or fraction of vehicles that receive at least one valid (as determined by the RSD analyzer software) RSD reading on a vehicle that is matched by the license plate to a record in the registration database. The vehicle-specific-power values associated with these RSD readings could have any value. The RSD readings could be for vehicles that are operating at moderate load, at steady cruise, under deceleration, or under heavy acceleration. RSD data collection vendors use this definition of coverage.

[2] 1 Mg = 10^6 g = 1000 kg = 1 metric ton

- **Usable-VSP RSD coverage** – This refers to the number of vehicles or fraction of vehicles that receive at least one valid (as determined by the RSD analyzer software) RSD reading on a vehicle that is matched by the license plate to a record in the registration database, and the VSP is in the emissions-representative range of 5 to 25 kW/Mg. These RSD readings are only those associated with vehicles that are operating at moderate load.

From the RSD and VSP data collected in this study, we found that approximately 40% of the valid, DMV-matched RSD readings had VSPs in the range of 5 to 25 kW/Mg. This means that the Usable-VSP RSD Coverage value is about 40% of the Any-VSP RSD Coverage value. Therefore, when speaking with RSD industry representatives, it is important to remember that the fleet RSD coverage values that they speak of do not take into account VSP. For the purposes of selecting vehicles for Directing, Exempting, Calling-In, or Scrapping, or for characterizing the emissions of the fleet, only the RSD readings that have in-range VSPs should be used. For example, if an RSD industry representative states that he will provide 50% coverage of the fleet, the usable RSD values for the purposes of special strategies and characterizing the emissions of the fleet, will be for only about 20% (= 40% of 50%) of the vehicles in the fleet.

Registered vehicles in the fleet – Table 3-1a shows a breakdown of California's registered vehicles for Calendar Year 2004 by the five largest AQMDs for the statewide fleet and for the I/M fleet.[3] We treated the area outside of the five largest AQMDs as a single area, which we called Rest of State. In Calendar Year 2004, 1976 to 1998 model year vehicles would be subject to the I/M program. The counts of the I/M vehicles driving in the whole state, as estimated by EMFAC, are shown in the fourth column of Table 3-1a. We assumed that 10% of vehicles registered outside of the five largest AQMDs annually travel inside of those AQMDs, and that they would be measured by RSD at about the same rate as vehicles that are registered inside the five largest AQMDs. These are vehicles that would happen to get measured by RSD, even though they are not registered in areas where RSD measurements are being taken. The counts of the vehicles that are subject to I/M in the five largest AQMDs and the rest of the state and are driving in the five largest AQMDs are shown in the last column of Table 3-1a. In this analysis, we modeled the incremental benefits of RSD only for I/M vehicles operated inside the five largest AQMDs, which covers about 83% (=11,358,066/13,388,069) of the statewide I/M fleet.

Table 3-1a also shows that about 60% of the 18,982,879 vehicles driving in the five largest AQMDs, or 11,358,066 vehicles, are vehicles that are subject to I/M.

[3] The values are from EMFAC. Details of the EMFAC run are given in Appendix N of Reference 1. The EMFAC version used was EMFAC2007 working draft V2.20.8 Feb 10, 2005.

Table 3-1a. Registered Vehicles in California in 2004

Area	Statewide Fleet		Fleet Subject to I/M	
	Model Years 1965-2004		Model Years 1976-1998	
	Driving in the Whole State	Driving in the 5 Largest AQMDs	Driving in the Whole State	Driving in the 5 Largest AQMDs
Sacramento	825,792	825,792	494,098	494,098
San Diego	1,966,649	1,966,649	1,176,709	1,176,709
San Joaquin	2,056,954	2,056,954	1,230,742	1,230,742
South Coast	9,100,769	9,100,769	5,445,282	5,445,282
Bay Area	4,655,741	4,655,741	2,785,679	2,785,679
Rest of State	3,769,745	376,975	2,255,559	225,556
Total	22,375,650	18,982,879	13,388,069	11,358,066

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RSD Measurement Effort for the Large Program – Suppose we designed an RSD measurement program to annually achieve 50% Any-VSP RSD Coverage of the fleet driving in the five largest AQMDs, that is, to get 9,491,440 unique, valid, DMV-matched RSD readings. The characteristics of such a program can be considered by looking at Table 3-1b. The costs of "turn-key" RSD data are typically determined using the number of valid, DMV-matched data points the state desires. (This count is in the fifth column of Table 3-1b.) According to Table 3-1b, to achieve 50% Any-VSP RSD Coverage, the state would need to pay for 31,638,132 valid measurements that could be matched to vehicle registration records. This RSD program would annually provide 3,796,576 RSD measurements that could be used to characterize the emissions of the on-road fleet, which includes I/M vehicles and non-I/M vehicles. However, only about 60% of the vehicles driving in the five largest AQMDs are I/M vehicles. Therefore, this RSD program would annually provide 2,271,613 usable RSD measurements on I/M vehicles. This is only 17% of the 13,388,069 I/M vehicles driving in the state. These measurements could be used to select vehicles for special I/M strategies such as Calling-In, Directing, Exempting, and Scrapping. However, since only 17% of the vehicles in the I/M fleet would have usable RSD measurements, 83% of the I/M vehicles in the fleet would not have RSD measurements available to help with vehicle selection.

The scenario described by Table 3-1b is the large RSD coverage scenario we used for the example scenario calculations. At the bottom of the table the reader can see that in this high coverage scenario only about 5 out of 100 vehicles passing the RSD units would produce a usable data point (3,796,576 usable out of 70,306,961 sensed). That is because this scenario requires that 50% of the fleet receive a valid, DMV-matched RSD measurement while operating in an emissions-representative driving mode as defined by an in-range VSP of 5 to 25 kW/Mg. Such a high coverage with these criteria has never been achieved in practice. We have also calculated the needs for smaller RSD programs. The coverage numbers for these other scenarios are shown in Appendix A. We discuss these issues and how we arrived at the assumptions we use to account for this in Appendix B.

Table 3-1b. RSD Measurement Counts for the Large RSD Program (Any-VSP RSD Coverage = 50%) (Usable-VSP RSD Coverage = 20%)

Area	Subject to I/M, In-range-VSP, Unique, Valid, DMV-Matched	In-range-VSP, Unique, Valid, DMV-Matched	Unique, Valid, DMV-Matched	Valid, DMV-Matched	Valid	Raw
	60% of In-range VSP, Unique, Valid, DMV-Matched	40% of Unique, Valid, DMV-Matched	30.0% of Valid, DMV-Matched	60% of Valid	75% of Raw	
Sacramento	98,820	165,158	412,896	1,376,320	2,293,866	3,058,489
San Diego	235,342	393,330	983,325	3,277,748	5,462,914	7,283,885
San Joaquin	246,148	411,391	1,028,477	3,428,257	5,713,762	7,618,350
South Coast	1,089,056	1,820,154	4,550,384	15,167,948	25,279,913	33,706,551
Bay Area	557,136	931,148	2,327,870	7,759,568	12,932,613	17,243,484
Rest of State	45,111	75,395	188,487	628,291	1,047,151	1,396,202
Total	2,271,613	3,796,576[c]	9,491,440[b]	31,638,132[a]	52,730,220	70,306,961

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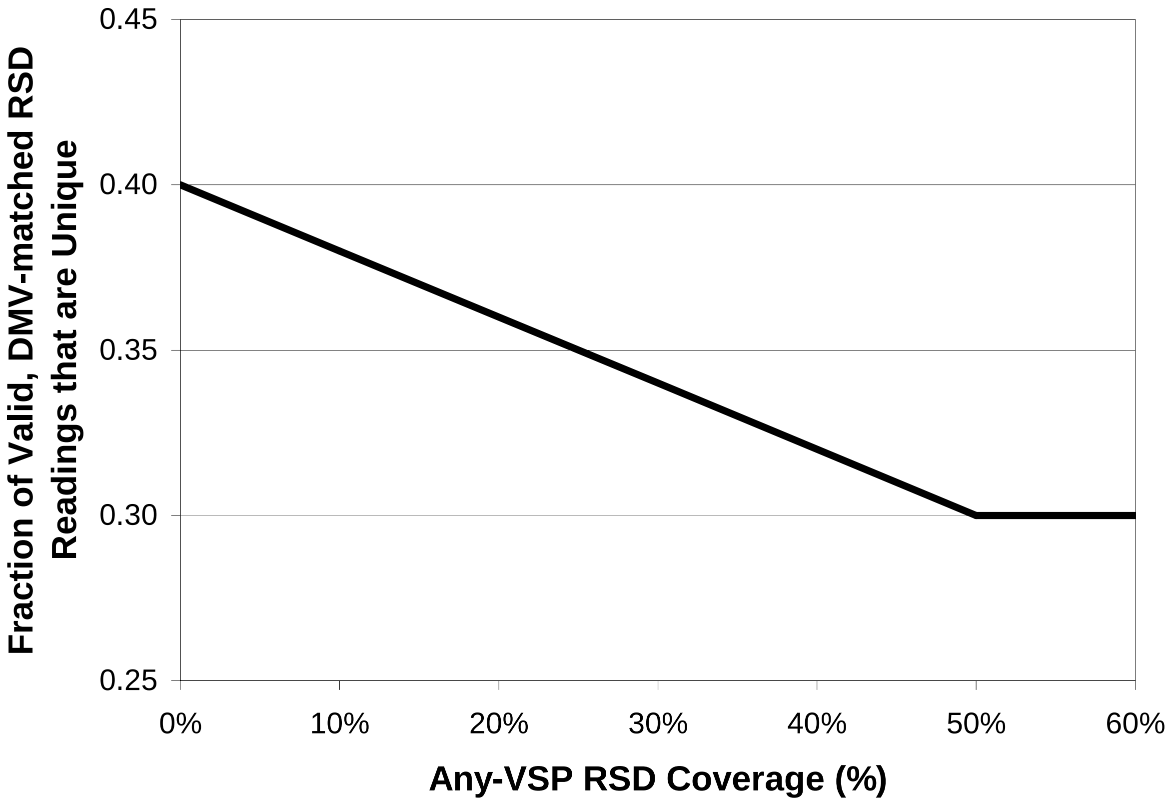
[a]Used to determine RSD data collection cost.
[b]Used to determine Any-VSP RSD Coverage.
[c]Used to determine Usable-VSP RSD Coverage.

For the 50% Any-VSP RSD Coverage situation shown in the Table 3-1b, we estimate that 30.0% of the valid, DMV-matched RSD measurements will be on unique vehicles. The reason that all of the RSD measurements are not on unique vehicles is because when the RSD collection effort tries to cover a larger portion of the fleet many of the RSD readings are actually replicate RSD measurements on the same vehicles. RSD measurement uniqueness probably depends on many factors including the quality of the measurement sites, the number of measurement sites, the length of time that an RSD unit spends at a site, and the Any-VSP RSD Coverage level that the data collection effort is trying to achieve. Figure 3-1 shows the function that we used to describe the uniqueness of valid, DMV-matched RSD readings for RSD data collection efforts of different Any-VSP RSD Coverages. This trend is based on uniqueness levels achieved in practice by RSD vendors.

Figure 3-1. RSD Measurement Uniqueness



/C:/MyDocuments/CA RSD pilot Decision report/Implementation Report/RSD uniqueness function.xls

4.0 Calculation of Benefits

Section 4.1 retrieves estimates of the relative changes in emissions, changes in failed miles driven, and the estimated failure rate of targeted vehicles from the modeling report [1]. Then, in Section 4.2 these relative changes are "ratioed up" to the size of the statewide I/M program fleet. In Section 4.3 the benefits for ranking methods are combined to produce benefits for full-fleet ranking methods. This produces a table of counts of targeted vehicles, targeted failing vehicles, and benefits (changes in tons of emissions and failed miles driven) based on the entire I/M fleet for different intervention activities and vehicle ranking methods.

4.1 Estimated Relative Changes in Benefits for Selected Basic Ranking Methods

The estimated percent changes in the evaluation criteria for selected fleet penetrations and for each of the intervention activities and basic ranking methods are shown in Table 4-1. These values were obtained by picking points from the appropriate evaluation performance curves in the modeling report [1]. We used only those data from the evaluations in the report where the evaluation criteria were calculated using Model D, which uses VID history and RSD measurement inputs and which we believe is the most accurate Fprob model. In addition, the benefits calculated using Model D will give maximum advantage to the influence of RSD measurements. Again, if adding RSD to the I/M program is not cost-effective under these conditions, then RSD's true incremental cost-effectiveness is probably lower.

Finally, we assume that the participation of vehicles in the special strategies is 100%. This means that we assume that all vehicles that are directed go to the high-performing stations, that all vehicles that are exempted will not come in for their regular I/M inspections, that all vehicles that are called-in will actually come in for their call-in ASM off-cycle test and if they fail they will receive repairs and meet the follow-up ASM requirements, and that all vehicles that are targeted for a scrappage ASM test will come in and receive the test and if they fail the scrappage ASM test, they will accept the scrappage offer and sell their vehicle to the State. To the extent that this 100% participation in the strategies is not achieved, the benefits of the strategies will be reduced. This means that for Calling-In, Directing, and Scrapping the real changes in failed miles driven, the real changes in FTP mass emissions, and the real fail rates at the Decision Point will be reduced relative to the values calculated in this report. For Exempting, the benefit of lower program costs would be reduced. It follows that the incremental changes produced by the addition of RSD information to other information that is used to select vehicles for these strategies will be smaller than the estimates of the RSD influences that are reported here. Thus, the size of the RSD influences that are reported here are the largest that we expect they could ever be in a real situation where an RSD measurement component is added to the existing California I/M program.

We know, for example, that based on the experience of other jurisdictions that only a fraction of vehicles that are called in would actually show up. Accordingly, the benefits calculated for the Calling-In strategy would be substantially less than calculated in this report. Similarly, one could expect that only a fraction of vehicle owners would respond to a request to bring in their vehicle for a scrappage ASM test and only a portion of those who do come in would accept the scrappage offer. The state of California already has experience with a Directing program and, therefore, has an estimate of the level of success that can be achieved with that strategy. In the case of Exempting, since it requires little action on the part of the vehicle owner, we expect that this strategy could achieve high participation rates.

Table 4-1 shows the estimated percent changes in FTP mass emissions (ΔFTP), changes in the failed miles driven (ΔFMD), and the failure rate of the targeted vehicles for each of the five different sets of vehicle ranking method inputs. The first three basic ranking methods (FprobDP by A, FprobDP by B, and ΔFMD by C) are methods that rank vehicles using model year, vehicle description, and VID history, respectively. None of these three methods use RSD information. As a result, most vehicles in the I/M fleet can be ranked by these methods. The other two basic ranking methods (FprobDP by F and ΔFMD by D) use RSD measurements for at least some of their inputs. These methods can be used for only that portion of the fleet where RSD measurements are available and will never apply to the entire fleet. In this and subsequent tables, ranking methods in bold denote ranking methods that require RSD inputs.

The best basic ranking methods are those in Table 4-1 that have the lowest values for benefits (ΔFTP and ΔFMD) taking sign into account. For Calling-In, Directing, and Exempting, ΔFMD by D is invariably the best performer. Specifically, for Calling-In and Directing, this method produces the largest reductions in FTP emissions and failed miles driven and for Exempting, this method allows the smallest quantity of emissions and failed miles driven to be exempted from inspection and repair. In the case of Scrapping, it is not possible to compare the relative performances of the basic ranking methods using Table 4-1 since spending $16 million biennially to purchase vehicles for Scrapping in different implementation situations produces different penetrations, which greatly influence the apparent performances of the basic ranking methods.

Table 4-1. Estimated Percent Changes in Evaluation Criteria for Selected Fleet Penetrations (Truth ≈ Model D)

Basic Ranking Method	Fleet Sample Penetration (%)	Benefits: %ΔFTP Emissions (%) — Change in FTP Mass Emissions as a percentage of the Normal I/M Process FTP Mass Emissions: HC	CO	NX	Benefits: %ΔFMD (%) — Change in Failed Miles Driven as a percentage of the Normal I/M Process Failed Miles Driven	Targeted Vehicle Failure Rate (%) — Targeted Vehicles That Would Fail an ASM at the Decision Point
Calling-In No-Sticker						
FprobDP by A	5	-0.39	-0.45	-0.23	-0.83	29.3
FprobDP by B	5	-0.41	-0.43	-0.23	-1.00	34.6
ΔFMD by C	5	-1.02	-0.57	-0.55	-3.18	33.2
FprobDP by F	5	-0.87	-0.47	-0.29	-1.40	43.5
ΔFMD by D	5	-1.21	-0.65	-0.64	-3.61	40.0
	100	-4.16	-2.88	-2.78	-8.40	10.2
Directing						
FprobDP by A	40	-6.91	-4.91	-3.81	-12.81	18.9
FprobDP by B	40	-6.93	-4.97	-3.84	-14.19	20.1
ΔFMD by C	40	-7.57	-5.05	-4.40	-15.66	17.3
FprobDP by F	40	-7.85	-4.97	-4.10	-14.98	20.5
ΔFMD by D	40	-8.62	-5.57	-4.75	-17.52	20.1
	100	-11.28	-7.61	-7.35	-20.21	10.2
Exempting						
FprobDP by A	20	0.91	0.57	0.83	1.06	1.7
FprobDP by B	20	1.08	0.69	1.03	0.70	1.0
ΔFMD by C	20	0.59	0.48	0.66	0.76	3.5
FprobDP by F	20	0.81	0.64	0.85	0.84	1.4
ΔFMD by D	20	0.34	0.29	0.45	0.10	2.0
	100	11.28	7.61	7.35	20.21	10.2
Scrapping						
FprobDP/$ by A	0.620	-0.917	-1.022	-0.461	-0.587	31.5
FprobDP/$ by B	0.480	-0.808	-0.923	-0.410	-0.610	36.9
ΔFTP CO/$ by C	0.440	-0.788	-0.942	-0.409	-0.621	38.9
FprobDP/$ by F	1.400	-2.608	-2.973	-1.495	-2.563	45.2
FprobDP/$ by F	0.430	-0.970	-1.104	-0.483	-0.722	44.9
ΔFTP CO/$ by C	0.430	-0.774	-0.926	-0.403	-0.610	39.0
ΔFTP CO/$ by D	0.420	-1.047	-1.239	-0.506	-0.832	48.6
ΔFTP CO/$ by C	0.420	-0.755	-0.906	-0.391	-0.595	38.9
	100.000	-22.524	-20.558	-17.446	-31.622	10.2

4.2 Estimated Absolute Changes in Benefits for Selected Basic Ranking Methods

Estimates of statewide I/M program fleet characteristics are needed to convert the relative changes in benefits, which were summarized in the previous subsection, into the absolute incremental costs and benefits of adding intervention activities to the I/M program. To arrive at these characteristics, we made an EMFAC run for the 2004 calendar year, which is the period during which most of the RSD measurements were taken in this study. Table 4-2 shows a summary of the EMFAC results[4] for LDAs, LDT1s, LDT2s, and MDVs, which are the vehicle types that are eligible for the I/M program.

Table 4-2. Fleet Characteristics for Calendar Year 2004.

Model Years	Exhaust HC (tons/day)	CO (tons/day)	NX (tons/day)	Vehicles	VMT (miles/day)
1965-2004	391.5	6,332	601.4	22,375,650	726,291,667
1976-2004	311.4	5,444	548.1	21,736,869	715,766,772
1976-1998	281.8	4,644	466.4	13,388,069	385,661,051

Table 4-2 shows that the statewide fleet for these vehicle types is made up of 22,375,650 vehicles. During this study in 2004, the I/M fleet covered 1976 to 1998 model years. Table 4-2 indicates that the I/M fleet has 13,388,069 I/M-eligible vehicles that emit 281.8 tons of exhaust HC, 4,644 tons CO, and 466.4 tons NX per day.

Accounting for Evaporative Emissions Benefits – When vehicles participate in special strategies they are selected because of measurements or forecasts regarding their tailpipe emissions. However, when vehicles participate in special strategies, they may inadvertently get evaporative emissions repairs since evaporative emissions component inspection is a routine part of vehicle inspections in the I/M program. The repairs are "inadvertent" because the set of the vehicles that are selected for elevated tailpipe emissions are merely correlated with the set of vehicles that have elevated evaporative emissions. Nevertheless, we would like to estimate the effect on benefits of vehicle participation in the special strategies so that the strategy can take credit for the reduction in evaporative HC emissions. According to EMFAC, the exhaust emissions levels of the I/M fleet are given by the last row in Table 4-2. In addition, EMFAC calculates that the evaporative HC emissions of the I/M fleet is 218 tons/day. When a vehicle

[4] Additional details of the EMFAC run are given in Appendix N of Reference 1. The EMFAC version used was EMFAC2007 working draft V2.20.8 Feb 10, 2005.

participates in special strategies, only a portion of this 218 tons will be available for detection. But how do we estimate what portion is available for selection?

After a regular I/M inspection, the evaporative and exhaust emissions of vehicles in the fleet tend to increase again from their reduced levels. This occurs naturally in the biennial period between regular I/M inspections. We surmise that the ratio of the increase in evaporative emissions to the increase in exhaust emissions following an inspection cycle is relatively constant. If we could estimate the ratio by using EMFAC, then we could estimate the tons of evaporative emissions available for reduction by the special strategies by multiplying the ratio by the tons of exhaust emissions benefits of the special strategies estimated by our exhaust emissions models. Unfortunately, EMFAC does not calculate the increases in emissions if the I/M program is discontinued or for the biennial period between inspection cycles. However, EMFAC does calculate the decreases in exhaust and evaporative emissions for situations when the I/M program is started in different past years. We can use this EMFAC capability to make an estimate of the ratio of changes in evaporative emissions to exhaust emissions.

Table 4-3 shows the results of two EMFAC runs for the 2004 calendar year I/M fleet – one run for the No-IM case and one run for the case where the I/M program was started in 2002. By comparing the estimated fleet emissions of these two cases, the table shows that for every 204 tons of HC + NX tailpipe emissions reduction, 22 tons of evaporative HC emissions reduction is expected. If we apply this ratio to the exhaust HC + NX inventory value of 748 (= 281.8 + 466.4) tons/day from Table 4-2, we expect that the amount of evaporative HC emissions that is available for selection by special strategies is 80.7 tons/day (= 748 * 22 / 204). This estimate of 80.7 tons is 37% of EMFAC's estimated evaporative HC emissions inventory value. Accordingly, the estimated total amount of HC available for capture by special strategies is 362.5 tons/day, which is the exhaust HC of 281.8 tons plus the evaporative HC of 80.7 tons.

Table 4-3. EMFAC Emissions Estimates of 2004 I/M Fleet

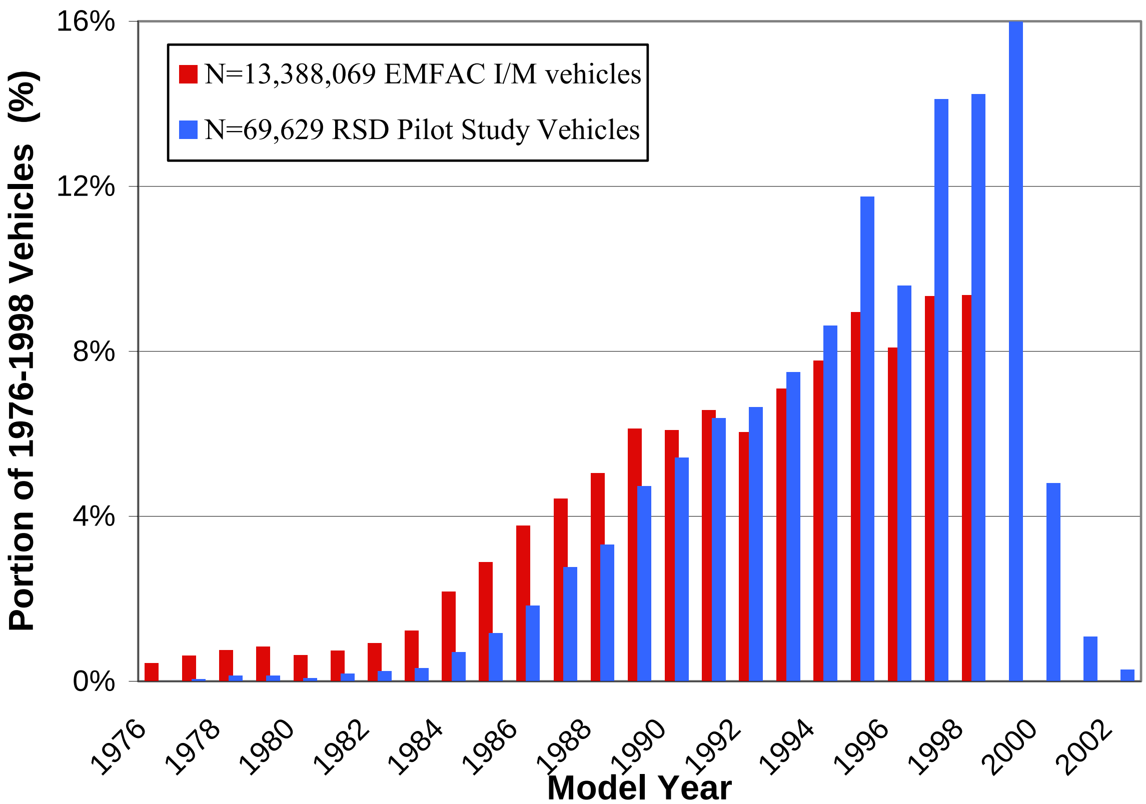
	Exhaust Emissions (tons/year)				Evaporative Emissions (tons/year)	Change with respect to the No-IM Case	
IM Case	**TOG**	**CO**	**NX**	**TOG +NX**	**Evap HC**	**TOG +NX**	**Evap HC**
No-IM	413	6101	650	1063	303		
2002 Start Biennial	327	5061	531	858	281	204	22

Comparison of the Modeling Set and the I/M Fleet – Before we apply the benefits calculated for the 69,629-vehicle dataset to the 13,388,069-vehicle I/M fleet, we need to consider the properties of the study's modeling dataset (N = 69,629). These particular observations were arrived at by a series of filterings of the raw data that were necessary to qualify the observations for use in evaluating the incremental costs and benefits of an RSD component to the existing I/M program.

Of the original 2,231,515 raw RSD readings taken from March 15, 2004 through January 24, 2005, 827,487 had valid RSD readings and had in-range VSPs. To ensure proper matching to the registration and VID databases and to allow for the determination of vehicle description including engine and emission control system technologies, we further required that these observations had to have non-erroneous VIN decodes. This reduced the number of observations to 486,286. To be able to use the observations for modeling, the RSD measurement had to be followed by an initial-cycle, naturally occurring ASM measurement. Because the analysis of the study occurred only about five months after the last RSD measurement was taken, most of the vehicles that had an RSD measurement did not have a long period of time during which a regular I/M inspection would have naturally occurred. Accordingly, the imposition of this requirement caused the 486,286 observations to drop to 90,574 observations. It should be noted that if the analysis would be performed today, which is more than two years after the end of RSD measurements, we expect that approximately 250,000 observations would be in the dataset. Also, the RSD had to be taken after the completion of a previous I/M cycle to ensure that the vehicle was not still undergoing repairs at the time of the RSD. Finally, all observations had to be able to produce forecasted failure probabilities using all of the types of models developed in the study. This meant that the observations had to have RSD measurements and unambiguous VID records for the cycles before and after the RSD measurement. These last two requirements caused the number of observations to drop to the final 69,629.

In these calculations, we are using the 69,629-vehicle dataset to represent the I/M fleet. However, the dataset needs to represent more than just the I/M fleet. It also needs to represent the sort of data that would be collected in an RSD program in California. It is well known that, because newer vehicles are more likely to be seen in any location because newer vehicles drive more miles per year than older vehicles, and because RSD measurements are typically taken on on-ramps to busy highways, newer model years are more abundant in RSD datasets than they are in the I/M fleet. Figure 4-1 shows a model year comparison for the 69,629-vehicle dataset and the 2004 calendar year I/M fleet as modeled by EMFAC. For the 2004 calendar year, the I/M eligible vehicles have model years from 1976 to 1998. The figure shows the portion of each of the sets that is present in each model year in comparison with the number of vehicles in the I/M-eligible model year range from 1976 to 1998. A comparison of the model year distributions in Figure 4-1 reveals two main trends.

Figure 4-1. Comparison of the Model Year Distribution of the EMFAC I/M Fleet and the Study Modeling Set



First, the RSD pilot study vehicles have observations for model years 1999, 2000, 2001, and 2002. These model year vehicles would not normally be considered part of the routinely biennially inspected I/M vehicles since the newest six model years are exempt from biennial participation in the I/M program. However, some newer model year vehicles will participate in the change of ownership portion of the I/M program. We believe that this may be the reason that 2000, 2001, and 2002 ASM inspections were performed on some of the vehicles in the dataset. A large number of 1999 vehicles also appear in the dataset. We believe that these vehicles may arise because they were the first inspections of vehicles beginning to participate in the biennial I/M program since their six year exemption period had just ended. This was a consequence of the RSD measurement portion of the pilot study ending in January 2005.

The second noticeable feature in the comparison of model year distributions in Figure 4-1 is that the 69,629-vehicle dataset is less abundant for vehicles with model years older than about

1990 in comparison with the I/M fleet. An argument can be made that because these two distributions do not have abundances that agree in the older model years, then the 69,629 vehicle dataset does not represent the I/M fleet. However, it is important to recognize that the modeling dataset is largely a consequence of the new-vehicle bias that will be present in any real RSD data. If we would increase the abundance of observations in the modeling dataset for vehicles with model years older then 1990 so that it matched the distribution of the I/M fleet, this would bias the benefits that could be achieved by adding an RSD component to the existing I/M program. The reason for this is that, in practice, increasing the abundance of RSD measurements on old vehicles with respect to the abundance of RSD measurements in new vehicles can only be obtained by using RSD data collection strategies that are different from the strategies used in this study and in other standard RSD data collection efforts. For example, one such strategy would be to collect RSD data at locations that older model vehicles frequent such as back roads away from busy highways. We expect that such an approach would drive the unit cost of each valid, DMV-matched RSD measurement high because the traffic volume in those locations would be low.

Accordingly, rather than make any adjustments to the abundance of model years within the 69,629-vehicle dataset, we chose to use the dataset as it was and to ratio the benefits and costs calculated for that dataset up to the 13,388,069-vehicle I/M fleet.

Estimating Absolute Benefits – The 69,629-vehicle set used to estimate the benefits for the intervention activities is a sample of the 13,388,069-vehicle I/M fleet. Accordingly, the estimates of relative benefits for intervention activities that were calculated on the 69,629-vehicle set will be applied to the I/M fleet emissions shown in Table 4-4.

Table 4-4. I/M Fleet Emissions Available to Special Strategies for Calendar Year 2004

Model Years	HC	CO	NX	Vehicles	VMT
	(tons/day)	(tons/day)	(tons/day)		(miles/day)
1976-1998	362.5	4,644	466.4	13,388,069	385,661,051

The result of applying the EMFAC model run results to relative benefits in Table 4-1 are the absolute benefits shown in Table 4-5. In the third column of the table, the total number of targeted vehicles is simply the fleet penetrations times 13,388,069 vehicles. Since the 13,388,069-vehicle I/M fleet is inspected once every two years, we must calculate the mass emissions for two years and recognize that Table 4-5 applies to one biennial cycle. The ΔFTP

HC, CO, and NX are a result of multiplying the emissions in the bottom row of Table 4-4 times the percent ΔFTP values in Table 4-1 and converting the units from days to two years. Then, in Table 4-5, the ΔFTPs for HC and NX are added together to create the column labeled HC + NX.

The ΔFMD values in Table 4-5 were obtained by ratioing up the calculated ΔFMD values for the 69,629-vehicle dataset to the 13,388,069 vehicles in the I/M fleet. The number of targeted vehicles that failed the ASM at the decision point shown in Table 4-5 is calculated by multiplying the total number of targeted vehicles by the targeted vehicle fail rate given in Table 4-1.

Table 4-5. Estimated Absolute Changes in Evaluation Criteria Over One Biennial Cycle

Basic Ranking Method	Fleet Sample Penetration (%)	Total Number of Targeted Vehicles	Benefits: ΔFTP Emissions (tons/2-years) HC	CO	NX	HC + NX	ΔFMD (miles/2-years)	Targeted Vehicles That Would Fail an ASM at the Decision Point
Calling-In No-Sticker								
FprobDP by A	5	669,403	(1,036)	(15,376)	(783)	(1,819)	(255,391,460)	196,205
FprobDP by B	5	669,403	(1,079)	(14,502)	(776)	(1,855)	(306,632,874)	231,709
ΔFMD by C	5	669,403	(2,711)	(19,397)	(1,884)	(4,595)	(972,447,180)	222,039
FprobDP by F	5	669,403	(2,294)	(15,919)	(990)	(3,284)	(428,918,410)	291,441
ΔFMD by D	5	669,403	(3,189)	(22,033)	(2,166)	(5,355)	(1,106,109,594)	267,510
	100	13,388,069	(11,005)	(97,598)	(9,451)	(20,456)	(2,573,103,949)	1,367,197
Directing								
FprobDP by A	40	5,355,228	(18,289)	(166,368)	(12,970)	(31,259)	(3,923,356,374)	1,013,987
FprobDP by B	40	5,355,228	(18,351)	(168,606)	(13,077)	(31,429)	(4,344,129,965)	1,079,009
ΔFMD by C	40	5,355,228	(20,023)	(171,066)	(14,969)	(34,992)	(4,796,437,902)	928,068
FprobDP by F	40	5,355,228	(20,766)	(168,549)	(13,944)	(34,709)	(4,587,782,887)	1,098,278
ΔFMD by D	40	5,355,228	(22,805)	(188,665)	(16,173)	(38,978)	(5,364,493,225)	1,078,481
	100	13,388,069	(29,842)	(257,953)	(25,023)	(54,864)	(6,190,213,623)	1,367,197
Exempting								
FprobDP by A	20	2,677,614	2,404	19,216	2,824	5,228	323,553,009	44,901
FprobDP by B	20	2,677,614	2,865	23,274	3,493	6,357	215,246,821	26,507
ΔFMD by C	20	2,677,614	1,553	16,309	2,251	3,803	231,898,446	94,147
FprobDP by F	20	2,677,614	2,138	21,531	2,889	5,026	255,910,070	37,671
ΔFMD by D	20	2,677,614	897	9,927	1,520	2,417	30,687,305	53,780
	100	13,388,069	29,842	257,953	25,023	54,864	6,190,213,622	1,367,197
Scrapping								
FprobDP/$ by A	0.620	83,006	(2,426)	(34,641)	(1,571)	(3,997)	(179,679,066)	26,182
FprobDP/$ by B	0.480	64,263	(2,138)	(31,290)	(1,395)	(3,533)	(186,801,268)	23,710
ΔFTP CO/$ by C	0.440	58,908	(2,084)	(31,943)	(1,394)	(3,478)	(190,210,114)	22,936
FprobDP/$ by F	1.400	187,433	(6,900)	(100,789)	(5,089)	(11,989)	(784,918,814)	84,775
FprobDP/$ by F	0.430	57,569	(2,566)	(37,419)	(1,643)	(4,210)	(221,091,610)	25,828
ΔFTP CO/$ by C	0.430	57,569	(2,048)	(31,385)	(1,371)	(3,419)	(186,914,495)	22,474
ΔFTP CO/$ by D	0.420	56,230	(2,770)	(42,019)	(1,723)	(4,493)	(254,816,023)	27,322
ΔFTP CO/$ by C	0.420	56,230	(1,997)	(30,723)	(1,332)	(3,330)	(182,280,015)	21,900
	100.000	13,388,069	(59,601)	(696,953)	(59,400)	(119,001)	(9,683,917,176)	1,367,197

4.3 Biennial Incremental Benefits for Full-Fleet Ranking Methods

As mentioned earlier, because two basic ranking methods (FprobDP by F and ΔFMD by D) require RSD inputs, they cannot be used to rank the majority of vehicles in the fleet. They are not full-fleet ranking methods. The reason for this is that for a large RSD measurement program in California, usable-VSP RSD measurements can be obtained on no more than about 17% of the I/M vehicles driving statewide.

We want to evaluate the costs and benefits of ranking methods that will cover the full I/M fleet. For the 17% of the I/M fleet with usable-VSP RSD measurements, vehicles can be targeted by using basic ranking methods that take advantage of the RSD information, but the remaining 83% of the I/M fleet vehicles can be targeted only with basic ranking methods that do not use RSD information. Because the two basic ranking methods that require RSD information can cover, at most, 17% of the statewide I/M fleet, we need to create two full-fleet ranking methods from them. These two "mixed" methods allocate 17% of vehicle ranking by basic ranking methods that require RSD inputs and 83% of the vehicles by the best basic ranking method that does not require RSD information (ΔFMD by C). When we apply this mixing to the estimated absolute changes in benefits shown in Table 4-5, Table 4-6 is produced.

The table shows the full-fleet ranking methods that require RSD input information as the bold text in the first column. The first mixed ranking method, which is made up of 17% of FprobDP by F and 83% of Nothing, reflects the benefits that could be achieved if only RSD measurements are used to select vehicles for the intervention strategies. The second mixed ranking method is made up of 17% of FprobDP by F and 83% of ΔFMD by C. The third mixed ranking method is 17% by ΔFMD by D plus 83% of ΔFMD by C. All of the values in Table 4-6 are simple linear combinations of the values in Table 4-5 using 17% and 83% as weighting factors.

Table 4-7 shows the biennial incremental benefits for the full-fleet ranking methods that are derived from the benefits shown in Table 4-6. In Table 4-7 we no longer use full-fleet ranking method descriptions based on the technical name, which uses ranking variable and model identifier. Instead, we use descriptions that reflect the inputs that are used to make the vehicle rankings. Table 4-7 becomes a key table for the estimation of costs and benefits for the five different full-fleet ranking methods.

Table 4-6. Changes in Evaluation Criteria Over One Biennial Cycle for Full-Fleet Ranking Methods

Full-Fleet Ranking Method	Fleet Sample Penetration (%)	Total Number of Targeted Vehicles	Benefits: ΔFTP HC + NX Emissions (tons/2-years)	Benefits: ΔFMD (miles/2-years)	Targeted Vehicles That Would Fail an ASM at the Decision Point
Calling-In No-Sticker					
FprobDP by A	5	669,403	(1,819)	(255,391,460)	196,205
FprobDP by B	5	669,403	(1,855)	(306,632,874)	231,709
ΔFMD by C	5	669,403	(4,595)	(972,447,180)	222,039
16.97% FprobDP by F + 83.03% Nothing	5	113,581	(557)	(72,776,491)	49,450
16.97% FprobDP by F + 83.03% ΔFMD by C	5	669,403	(4,372)	(880,224,241)	233,814
16.97% ΔFMD by D + 83.03% ΔFMD by C	5	669,403	(4,724)	(995,126,275)	229,754
	100	13,388,069	(20,456)	(2,573,103,949)	1,367,197
Directing					
FprobDP by A	40	5,355,228	(31,259)	(3,923,356,374)	1,013,987
FprobDP by B	40	5,355,228	(31,429)	(4,344,129,965)	1,079,009
ΔFMD by C	40	5,355,228	(34,992)	(4,796,437,902)	928,068
16.97% FprobDP by F + 83.03% Nothing	40	908,645	(5,889)	(778,429,490)	186,350
16.97% FprobDP by F + 83.03% ΔFMD by C	40	5,355,228	(34,944)	(4,761,034,480)	956,948
16.97% ΔFMD by D + 83.03% ΔFMD by C	40	5,355,228	(35,668)	(4,892,822,371)	953,589
	100	13,388,069	(54,864)	(6,190,213,623)	1,367,197
Exempting					
FprobDP by A	20	2,677,614	5,228	323,553,009	44,901
FprobDP by B	20	2,677,614	6,357	215,246,821	26,507
ΔFMD by C	20	2,677,614	3,803	231,898,446	94,147
16.97% FprobDP by F + 83.03% Nothing	20	454,323	853	43,421,398	6,392
16.97% FprobDP by F + 83.03% ΔFMD by C	20	2,677,614	4,011	235,972,605	84,565
16.97% ΔFMD by D + 83.03% ΔFMD by C	20	2,677,614	3,568	197,758,058	87,298
	100	13,388,069	54,864	6,190,213,622	1,367,197
Scrapping					
FprobDP by A / $	0.620	83,006	(3,997)	(179,679,066)	26,182
FprobDP by B / $	0.480	64,263	(3,533)	(186,801,268)	23,710
ΔFTP CO by C / $	0.440	58,908	(3,478)	(190,210,114)	22,936
16.97% FprobDP/$ by F + 83.03% Nothing	1.400	31,803	(2,034)	(133,180,660)	14,384
16.97% FprobDP/$ by F + 83.03% ΔFTP CO/$ by C	0.430	57,569	(3,553)	(192,713,478)	23,043
16.97% ΔFTP CO/$ by D + 83.03% ΔFTP CO/$ by C	0.420	56,230	(3,527)	(194,587,521)	22,820
	100.000	13,388,069	(119,001)	(9,683,917,176)	1,367,197

Table 4-7. Biennial Incremental Benefits for Full-Fleet Ranking Methods

	Full-Fleet Ranking Method Description	Intervention Activity: Calling-In No-Sticker	Directing [1,2]	Exempting [2]	Scrapping
ΔFTP HC+NX Emissions (tons/ 2years)	Model Year [a]	(1,819)	(3,876)	3,241	(3,997)
	Vehicle Description [b]	(1,855)	(3,897)	3,942	(3,533)
	VID History [c]	(4,595)	(4,339)	2,358	(3,478)
	RSD [f] + Nothing	(557)	(730)	529	(2,034)
	RSD [f] + VID History [c]	(4,372)	(4,333)	2,487	(3,553)
	VID/RSD [d] + VID History [c]	(4,724)	(4,423)	2,212	(3,527)
ΔFMD (miles/2years)	Model Year [a]	(255,391,460)	(486,496,190)	200,602,866	(179,679,066)
	Vehicle Description [b]	(306,632,874)	(538,672,116)	133,453,029	(186,801,268)
	VID History [c]	(972,447,180)	(594,758,300)	143,777,037	(190,210,114)
	RSD [f] + Nothing	(72,776,491)	(96,525,257)	26,921,267	(133,180,660)
	RSD [f] + VID History [c]	(880,224,241)	(590,368,275)	146,303,015	(192,713,478)
	VID/RSD [d] + VID History [c]	(995,126,275)	(606,709,974)	122,609,996	(194,587,521)
Targeted Vehicles That Would Fail an ASM at the Decision Point	Model Year [a]	196,205	125,734	27,839	26,182
	Vehicle Description [b]	231,709	133,797	16,435	23,710
	VID History [c]	222,039	115,080	58,371	22,936
	RSD [f] + Nothing	49,450	23,107	3,963	14,384
	RSD [f] + VID History [c]	233,814	118,662	52,430	23,043
	VID/RSD [d] + VID History [c]	229,754	118,245	54,125	22,820

[1]We assume that average-performing stations have 80% of the accuracy of high-performing stations. Therefore, high-performing stations will produce 20% more fails than average-performing stations. Accordingly, the incremental benefits caused by Directing are estimated at 20% of the full values for ΔFTP, ΔFMD, and number of targeted vehicles that would fail an ASM at the decision point found in Table 4-6.

[2]We assume that 62% of the vehicles would be eligible for Directing and Exempting about a month before their biennial anniversary. This is mainly caused by vehicles that receive change-of-ownership inspections earlier in the cycle. Accordingly, the incremental benefits caused by Directing and Exempting are estimated at 62% of the full values for ΔFTP, ΔFMD, and number of targeted vehicles that would fail an ASM at the decision point found in Table 4-6.

Basic Ranking Method	CN, DI, EX	SP
[a] Model Year	= FprobDP by A	= FprobDP/$ by A
[b] Vehicle Description	= FprobDP by B	= FprobDP/$ by B
[c] VID History	= ΔFMD by C	= ΔFTP CO/$ by C
[d] VID/RSD	= ΔFMD by D	= ΔFTP CO/$ by D
[e] RSD	= FprobDP by F	= FprobDP/$ by F

Adjustments for the benefits of Directing and Exempting – The benefits for Calling-In and Scrapping in Table 4-7 are exactly the same as those in Table 4-6. However, two adjustments for Directing and one adjustment for Exempting are required because of the way we estimated the base benefits in the modeling report.

The first adjustment affects the Directing values for ΔFTP, ΔFMD, and number of failed vehicles. The size of the benefit of Directing is proportional to the difference in performance of the station from which and to which a vehicle is directed. Clearly, if there is no difference in station performance, directing a vehicle provides no benefit. In the modeling report [1], for the purposes of estimating the base benefits for Directing, we assumed that high-performing stations performed accurate inspections and we assumed that average-performing stations performed completely useless inspections with no repairs being made. We do not believe either of these assumptions is actually true, but making the assumptions made the calculations simpler. The result of these assumptions is that the values for the three criteria for Directing in Table 4-6 over-estimate the benefits of Directing. Accordingly, for Table 4-7 we now need to correct for the over-estimations that were the result of the assumptions.

BAR has done several studies that rank stations by performance and compare the ranges of performance [2, 3, 4]. Based on the trends observed in those studies, in this study we have assumed that average-performing stations are about 80% as effective as high-performing stations in terms of emissions reductions, failed miles driven, and fail rates. Thus, we estimate that the difference in performance of the station from which and to which a vehicle is directed is 20% (= 100% - 80%). Therefore, the estimated benefits in Table 4-6 are multiplied by 0.2 (=20%) to produce the values for Directing in Table 4-7, which are thereby corrected for the over-estimation of Directing benefits calculated in the modeling report.

The second adjustment affects Directing and Exempting values for ΔFTP, ΔFMD, and number of failed vehicles. In the modeling report [1], for the purposes of estimating the base benefits for Directing and Exempting, we assumed that all vehicles for model years 1976-1998 would be eligible for Directing and Exempting. Vehicles that are actually eligible for Directing and Exempting are only those vehicles that have not already gotten an inspection about a month before their biennial anniversary. Thus, vehicles that already received change-of-ownership inspections or were newly registered vehicles would not be eligible. To the extent that a portion of the vehicles have already gotten an I/M inspection or are otherwise ineligible for Directing and Exempting, the base benefits of Directing and Exempting calculated in the modeling report are an over-estimation of the true benefits. The result of this assumption is that the values for the three criteria for Directing and Exempting in Table 4-6 over-estimate the benefits of Directing and Exempting. Accordingly, for Table 4-7 we now need to correct for the over-estimations that were the result of the assumption.

Based on partial 2005 initial I/M inspection results, BAR estimated that 27.5% of the vehicles in the I/M fleet had change-of-ownership initial inspections and 10.3% of the vehicles had initial-registration initial inspections. Only the remaining 62.2% of the vehicles received biennial initial inspections and were eligible for Directing and Exempting. Accordingly, the incremental benefits of Directing and Exempting shown in Table 4-7 need to be reduced to 62% of the values to account for Directing and Exempting eligibility.

In summary, for Directing the values in Table 4-7 are reduced to 20% times 62% of the values in Table 4-6. For Exempting the values in Table 4-7 are reduced to 62% of the values in Table 4-6.

Table 4-7 shows the estimated benefits of the four intervention activities in terms of ΔFTP and ΔFMD over one biennial cycle. To put these changes in perspective, we show Table 4-8, which gives estimates of the biennial total FTP emissions [from the EMFAC run results in Appendix N of Reference 1], total failed miles driven (FMD), and total vehicle miles traveled (VMT) for the 13,388,069-vehicle I/M fleet as it operated in 2004.

Table 4-8. Biennial Estimates of FTP Emissions, Failed Miles Driven, and Vehicle Miles Traveled for the I/M Fleet

FTP Emissions (tons/2years)	**HC**	205,714
	CO	3,390,120
	NX	340,472
	HC + NX	546,186

FMD (miles/2years)	30,624,179,635
VMT (miles/2years)	331,568,758,801

5.0 Calculation of Costs

Sections 5.1 through 5.5 discuss RSD measurement unit costs, central office costs, the estimated value of vehicles targeted for scrappage, vehicle repair costs, and other costs for components needed by any intervention activities in the California I/M program. These unit costs are retrieved from a cost analysis study. We supplement these costs results with the experiences of other jurisdictions that have been making RSD measurements. In Section 5.6, we use the example scenario, which has the chosen mix of intervention activities to be investigated, and the base case scenario, which has no intervention strategy, to define the level of cost item use required to implement each intervention activity. Then, in Section 5.7, we multiply the unit cost for each cost item by the needed number of cost items to arrive at the different components of the biennial incremental costs for implementing the example scenario.

5.1 Estimates of RSD Measurement Unit Costs

In this section we describe how the estimates for costs of RSD measurements were arrived at. A number of assumptions are required to estimate the costs of a hypothetical program. Some assumptions come with implications that are not obvious. We have listed the major assumptions that readers should keep in mind as they evaluate the options of using RSD to improve Smog Check:

- Cost and fleet coverage estimates assume the programs have been largely accepted by the public (i.e., drivers do not try to avoid RSD sites or attempt to invalidate the measurement, they respond to the notices for off-cycle inspection, etc.).

- Costs do not include enforcement (e.g., BAR responses to program avoidance, fighting legal challenges of the validity of the RSD measurement, etc.).

- We assume the restrictions CalTrans placed upon our RSD measurement teams will be lifted. We were restricted from taking RSD measurements during rush hour traffic. Experience with other programs has shown that this restriction is unnecessary.

- We assume that the Sacramento area provides a good surrogate for assumptions about the availability of sites, the comparability between freeway and surface street sites, California driving behavior, etc.

Table 5-1 gives the estimated unit costs for five different types of RSD measurement programs. The unit cost of each RSD measurement is based on the volume of quality-assured measurements that are valid and matched to DMV records. The total RSD cost is proportional to the size of the program. The unit cost is for RSD data collection and delivery, which includes labor, RSD data quality assurance, support overhead, equipment maintenance, travel, operations, consumables, site selection, permits, license plate transcription, and matching to DMV records. The major assumptions and a description of the relevant sources for each cost element are listed in Table 5-2.

Table 5-1. Estimated Unit Costs for Different RSD Measurement Programs

Description of Turn-Key RSD Data Collection	Estimate ($/valid, matched)	Notes and Source
Manned, 50% Any-VSP RSD Coverage	$1.00	Projection from other programs for high coverage. Valid (per ESP software) and matched to DMV (including permits, equipment, maintenance, QA, etc.)
Manned, 35% Any-VSP RSD Coverage	$0.75 [a]	Similar to other programs. Valid (per ESP software) and matched to DMV (including permits, equipment, maintenance, QA, etc.)
Manned, low Any-VSP RSD Coverage	$0.50 [a]	Similar to annual 0.5% fleet coverage surveys. Valid (per ESP software) and matched to DMV (including permits, equipment, maintenance, QA, etc.)
Unmanned, 50% Any-VSP RSD Coverage	$0.42 [a,b]	Calculated from manned estimate using ratio of “manned” vs. “unmanned” estimates. Valid (per ESP software) and matched to DMV (including permits, equipment, maintenance, QA, etc.)
Unmanned, 35% Any-VSP RSD Coverage	$0.31 [a,b]	Calculated from manned estimate using ratio of “manned” vs. “unmanned” estimates. Valid (per ESP software) and matched to DMV (including permits, equipment, maintenance, QA, etc.)
[a]Estimates from current programs. [b]Unmanned calculated as ratio from manned ($/deployed RSD unit) vs. unmanned estimates.		

Table 5-2. Cost Elements and Notes on Assumptions

Cost Element	Sources	Notes
Quality Assured RSD data, matched to registration records	Project estimates, Other RSD programs	Includes equipment to collect valid data using manned systems. The project developed “ground-up” estimates for California. The project estimates were modified using experience from the pilot program and from other state programs. Site selection and permits are included.
Required number of RSD sites	Project estimates, Other RSD programs	California specific issues from the project study of Sacramento as typical. Ramps compared to surface streets from pilot program data (RSD-RASM report). Site productivity (valid readings per raw reading, fraction within desired VSP range, etc.) from pilot program data and experience of other RSD programs.

RSD unit cost increases as RSD fleet coverage increases because getting RSD measurements on the increasingly difficult-to-find unique vehicles means that RSD equipment must be set up at more and more, less-than-ideal RSD sites. To provide RSD unit cost estimates for manned RSD data collection over a wide range of fleet coverages, we have fit the first three unit costs in Table 5-1 with a second-order equation:

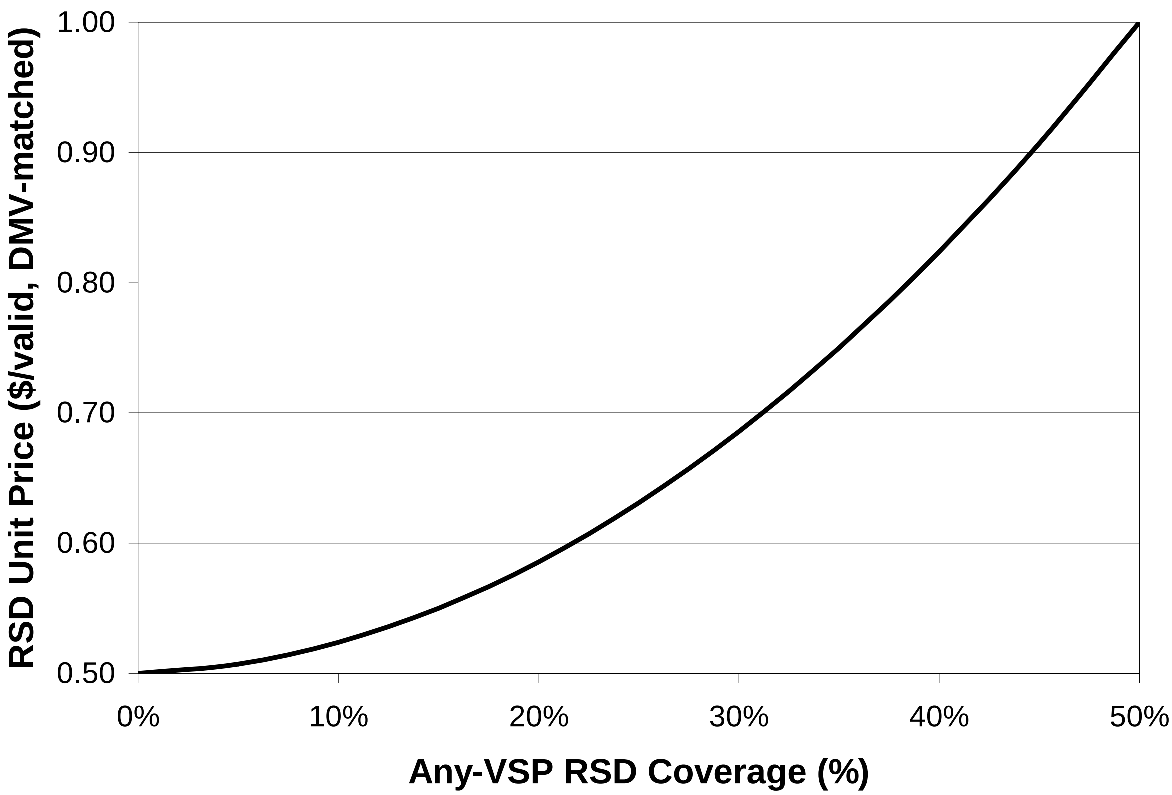
RSD Unit cost ($/valid, DMV-matched)

$$= 0.50 + 0.0475 * \left(\frac{\%\text{FleetCoverage}}{100\%}\right)$$
$$+ 1.9048 * \left(\frac{\%\text{FleetCoverage}}{100\%}\right)^2$$

where: % Fleet Coverage is the Any-VSP RSD Coverage.

A plot of the RSD unit cost function is shown in Figure 5-1.

Figure 5-1. Estimated RSD Unit Price for Turn-Key Measurements



C:/MyDocuments/CA RSD Pilot Discussion report/Implementation Report/RSD unit price function.xls

In parallel, our team also estimated the costs of RSD data using a "bottom up" method, which estimates the cost of each piece of the RSD data collection effort and then adds them. For example, we estimated the cost of the equipment, maintenance costs, consumables, labor, training, etc. Those estimates are not used verbatim in this report because the results did not come close enough to what we know to be the case from other programs. For example, our bottom up approach estimated a cost of almost $2.50 per valid reading, matched to the registration database for a program with a 10% any-VSP RSD coverage of the fleet.[5] We know from other programs that 30% any-VSP RSD coverage can be achieved for under $0.75 per valid, matched RSD reading. We expect that the bottom-up approach did not capture the efficiencies and real world experience of other RSD programs now in operation. We did, however, use many of the assumptions from our bottom-up estimate because they are unique to California and could not be estimated from the experience of other programs. These assumptions are discussed at the beginning of this sub-section.

Summary of RSD costs – Now that we have estimated the RSD unit costs, we can apply the unit costs to the estimated counts of RSD measurements from Table 3-1b to arrive at a RSD data collection cost. Table 5-3 shows the corresponding cost figures for the large, medium, and small RSD programs described in Appendix A. The table is laid out to follow the logic that would be used to cost the RSD data collection effort of an RSD component to the existing I/M program. Column A indicates the general size of the RSD program. In this report, we have been discussing a large RSD program. Column B quantifies that size in terms of the any-VSP RSD coverage. This coverage applies to the I/M and non-I/M California vehicles driving in the five largest AQMDs. For example, the large RSD program would have an any-VSP RSD coverage of 50%. In terms of the number of vehicles that would be covered, Column C shows the number of unique I/M and non-I/M vehicles with DMV-matched RSD readings. This number is simply determined by multiplying the any-VSP RSD coverage in Column B by the number of California I/M and non-I/M vehicles driving in the five largest AQMDs. To achieve that level of any-VSP

[5] The project calculated costs for a small program where readings would be obtained on 34,220 unique vehicles in the Sacramento area, where those vehicles are being operated in a "representative" driving mode. This translates to approximately 214,000 valid readings on vehicles that can be verified as being registered in California, and about 85,600 unique vehicles (about 10% of the 2004 Sacramento fleet). We estimated the cost of such a program at $532,000, or a little less than $2.50 per valid reading matched to the registration database.

Table 5-3. Comparison of RSD Programs of Different Size

A	B	C	D	E	F	G	H	I	J
	Desired		**Required**			**Achieved**			
	Any-VSP RSD Coverage	**Number of Unique I/M and non-I/M Vehicles with Valid, DMV-Matched RSD Readings**	**Number of Valid, DMV-Matched RSD Readings**	**RSD Unit Cost**	**Annual RSD Data Collection Cost**	**Number of Unique I/M vehicles Driving in the 5 Largest AQMDs that have at least one In-Range-VSP, Valid, DMV-Matched RSD Reading**	**Usable-VSP RSD Coverage of I/M Vehicles Driving in the 5 Largest AQMDs**	**Usable-VSP RSD Coverage of I/M Vehicles Driving in the Entire State**	**Effective RSD Cost**
RSD Program Size	**(% of California I/M and non-I/M vehicles driving in the 5 largest AQMDs)**	**(based on 18,982,879 California I/M and non-I/M vehicles driving in the 5 largest AQMDs)**		**($/ valid, DMV-matched RSD reading)**	**($)**		**(% of the 11,358,066 California I/M vehicles driving in the 5 largest AQMDs)**	**(% of the 13,388,069 California I/M vehicles driving in the State)**	**($/ IM vehicle with a usable RSD reading)**
Large	50%	9,491,440	31,638,132	$1.00	$31,638,132	2,271,613	20%	16.97%	$13.92
Medium	30%	5,694,864	16,749,599	$0.69	$11,485,402	1,362,968	12%	10.18%	$8.43
Small	10%	1,898,288	4,995,495	$0.52	$2,616,680	454,323	4%	3.39%	$5.76

C:/MyDocuments/CA RSD Pilot Decision Report/Implementation Report/Usable RSD Data Costs.xls

RSD coverage, a much larger number of valid, DMV-matched RSD readings is required. This is shown in Column D. The RSD unit costs are applied to these counts to determine the RSD data collection costs for the RSD program. The RSD unit costs, as described earlier in this section, are a function of the any-VSP RSD coverage percentage. Column E shows these estimated RSD unit costs for the different RSD program sizes. The annual RSD data collection cost, shown in Column F, is simply the value in Column D times the RSD unit cost in Column E.

Columns G through J show what is achieved by operating these different size RSD programs. Column G shows the number of unique I/M vehicles that are driving in the five largest AQMDs that have usable RSD readings, that is, RSD readings that can be used to select vehicles for Calling-In, Directing, Exempting, or Scrapping. When we express these counts in Column G as a percentage of the California I/M vehicles driving in the five largest AQMDs, we get the usable-VSP RSD coverage figures shown in Column H. If we express them in terms of the number of California I/M vehicles driving in the entire state, we get the usable-VSP RSD coverage percentages shown in Column I. Finally, Column J shows the effective RSD cost associated with a usable RSD reading on an I/M vehicle that is driving in the five largest AQMDs.

Overall, the table shows that annually the large RSD program costs more than $31.6 million to obtain 2.27 million RSD measurements that could be used to select vehicles for special strategies. Thus the average cost of RSD data collection for each usable RSD measurement is $13.92. Even at this price, this large RSD program provides usable-VSP RSD coverage of only 17% of the statewide I/M fleet. The data collection for the smaller size RSD programs is less expensive overall and less expensive per I/M vehicle with a usable RSD reading; however, even smaller portions of the I/M fleet are covered. This means that regardless of the size of the RSD program, less than 17% of the statewide I/M fleet is available to be selected for special strategies that use RSD data.

5.2 Estimates of Central Office Costs

This section describes our estimates of the costs for a central office that would select vehicles for Calling-In, Directing, Exempting, and/or Scrapping strategies that would supplement the existing I/M program. In the cost estimates we examined each of the different components of the central office costs. We developed functions that modify the component costs smoothly, but not necessarily proportionately, with the characteristics of the supplemental program. The resulting function can calculate costs for a small central office serving a small piece of the state all the way up to a full size office that would cover the entire state.

Assumptions – To calculate the central office cost, we made a few assumptions. First, the central office was assumed to be at a single location and housed at an existing state agency. The central office would be at one location regardless of the geographical scope of the fleet of vehicles that is covered by the central office. For example, we did not assume the presence of any branch central offices for separate AQMDs.

Vehicle selection strategies can operate with or without RSD data since VID history information can be used alone to select vehicles for any strategy. However, if RSD data is used, we assumed that an RSD contractor would provide RSD information in a turn-key manner. We assumed that the RSD contractor would provide data records for valid, DMV-matched RSD measurements with at least the following fields: hand-transcribed license plates, RSD measurements, and calculated vehicle specific power. In addition, we assumed that the contractor would provide this information on a weekly basis and that all of the RSD measurements would be fresh.

Finally, we assumed that the costs for purchasing scrappage vehicles, mailing notices, performing inspections, issuing certificates, repairing vehicles, and maintaining the central office's vehicle selection software are not part of the central office costs. Those costs are considered separately from the central office costs in later sections.

Central Office Activities – The central office would receive weekly updates of data from four sources:

- DMV registration updates;
- New VID records;
- Valid, DMV-matched RSD data (if RSD data is used); and
- Records of past notices sent to owners, and in the cases of Calling-In and Scrapping, records of subsequent action by the owner.

In addition to weekly updates for these data sources, historical records for each of the sources would be required to maintain information datasets for the purposes of calculating vehicle rankings and insuring that new notices are not sent to vehicle owners who have just recently received notices. We expect that the central office would need to keep the most recent two years of DMV registrations, six years of VID records, two years of RSD data, and two years of records of past notices sent and responses of owners to notices.

The central office would hire an RSD contractor to provide turn-key RSD data and its associated information. The cost of RSD data collection is estimated in Section 5.1 and is not a part of the central office cost described here. The central office would also assist the RSD contractor in working out problems that the contractor might have in selecting and gaining access to appropriate sites around the state to be used for RSD data collection. A data analyst at the central office would perform weekly checks on the RSD data obtained to ensure that data quality is maintained.

One of the main jobs of the central office would be to create weekly lists of targeted vehicles for Calling-In, Directing, Exempting, and Scrapping based on current VID history and/or RSD measurement information. The central office would make the list of targeted vehicles by selecting them from the list of all vehicles ranked by the expected benefits of selecting each eligible vehicle. Vehicle eligibility would be determined by the specific needs of the strategy. Directing and Exempting would apply only to vehicles that are soon due for their I/M inspection. Calling-In and Scrapping targeted vehicles would be eligible as long as the individual vehicle had not been targeted recently. Ranking of vehicles for targeting would be accomplished by running the computer programs developed in this project that forecast the benefits of selecting individual vehicles for specific strategies. This is true even for using RSD data alone since the ranking programs that we have built perform better (get more emissions) than using simple RSD cutpoints.

The first step in ranking vehicles is matching records among the different data sources. If RSD data is available for vehicle ranking, the central office would match RSD information with registration information, VID information, and past-notices-sent information. If RSD data is not available for vehicle ranking, the central office would match observations from registration information, VID information, and past-notices-sent information.

Each week the prior week's data would be used to create vehicle targeting lists for Calling-In, Directing, Exempting, and/or Scrapping. The Directing and Exempting target lists would be transmitted weekly to the agency that sends reminder notices to owners for their upcoming inspection. Vehicles that are directed or exempted would be sent modified notices. The Calling-In and Scrapping target lists would be transmitted to whomever would send those notices. Sending the notices is costed in Section 5.6 and is not a part of the central office cost described here.

The central office would also handle the questions from vehicle owners in response to the letters that they received which discussed Directing, Exempting, Calling-In, and Scrapping. We assumed that the level of effort required to handle owners targeted for Calling-In would be high and, therefore, would require additional central office personnel to handle owners' questions.

Because of the addition of supplemental strategies to the existing I/M program, the central office would also conduct public outreach and education activities.

Components of Central Office Costs – This project estimated different components of central office costs. These estimates were based on a hypothetical central office that would serve the Sacramento area. The cost estimates for serving other areas within California, including the entire state, are based upon these costs. Table 5-4 gives the different components of the costs for different configurations of a central office. Different configurations of the central office are defined by four variables:

- **Size of the program** – The size of the program is proportional to the number of I/M vehicles served by the central office. A value of 1 indicates a statewide program, a value of 0.037 indicates a program big enough to serve the Sacramento area, and a value of 0.4 indicates a program big enough to serve the South Coast AQMD.

- **Full fleet Calling-In targeting fraction** – This value indicates the fraction of the I/M fleet targeted for Calling-In. When this value is zero, no Calling-In is being performed. A value of 0.025 indicates that 2.5% of the I/M fleet would be targeted for Calling-In by sending call-in notices to 2.5% of the I/M fleet.

- **RSD data availability** – This is a binary (yes/no) value. A zero indicates that RSD data is not being used and only VID history information is being used. A one indicates that RSD data is being used, either alone or with VID history, for ranking and selecting vehicles.

- **Percent of vehicles with complete data for the selection method** – This value is the maximum fraction of the statewide I/M vehicles in the program (see "Size of the program," above) that can be evaluated by the selection method being used. A value of 100% indicates that all of the vehicles in the fleet have data that can be used by one vehicle ranking method or the other. The value of 16.97% is the maximum value that can be used for the ranking method using RSD information alone since the usable-VSP RSD coverage for the largest practical RSD program (any-VSP RSD coverage = 50%) is 16.97% of the statewide I/M fleet. A value of 3% is an example of the situation where 3% of the vehicles in the program would have a full set of data available for ranking. This would be the situation, for example, for targeting vehicles for scrappage using RSD alone when only 3% of the vehicles in the area being served have RSD information available.

Table 5-4 shows that the capital costs for the central office are split into three categories. The first item pays for programming changes and form changes for the Department of Motor Vehicles information. This is a one-time expense and would only occur if a Calling-In program were used. The same one-time expense would be incurred if a small central office or a statewide central office would be set up. The second capital expense is for the central office computer equipment. We expect that a server would be required to maintain weekly updates to the large datasets of Registration, VID, RSD, and historical notice datasets. In addition, each employee would need a desktop computer to communicate with the server. We have estimated these costs as $20,000 for the server plus $2,000 for each employee at the central office. The third capital cost is for central office supplies and equipment and is directly proportional to the number of employees at the central office.

The annual operating and maintenance costs have several categories. The first three shown in Table 5-4 are the amortized capital costs. The DMV programming and form change costs were amortized over 10 years at 10%. The computer costs were amortized over 5 years at 10%. The capital costs for office supplies and equipment were amortized over 10 years at 10%.

The major costs for operating the central office are the labor costs. We costed eleven different positions in the central office. For the estimated costs in this study, we have kept the same level of detail, but have grouped them into four categories for discussion:

- **Program Administrator/Program Manager** – The Program Administrator oversees the central office operation. The time that the Program Administrator works in the central office is dependent on the existence of a Calling-In program and the general size of the program. If Calling-In is one of the strategies in the program, then a full Program Administrator is required to oversee the handling of the responses from vehicle owners that have been targeted. If Calling-In is not in the program, that is, if the program contains only Directing, Exempting, and/or Scrapping, then the amount of time the Program Administrator spends in the central office is proportional to the size of the program. More than one Program Administrator is never required.

  If RSD data is used, a Program Manager will be required to maintain communications with the RSD contractor and to ensure that RSD data is quality-checked and is used properly. Additional Program Managers will be required in proportion to the size of the program if the Calling-In strategy is used.

Table 5-4. Central Office Costs for the Statewide Program for Calling-In, Directing, Exempting, and Scrapping

Full-Fleet Ranking Method Description	Annual Salary @ 40hrs/wk	Model Year		Vehicle Description		VID History		RSD + Nothing		RSD + VID History		VID/RSD + VID History	
Strategies?		D X S C		D X S C		D X S C		D X S C		D X S C		D X S C	
Size of Program (Statewide=1)		1		1		1		1		1		1	
% Sample Fleet Penetration for Calling-In		5%		5%		5%		5%		5%		5%	
With RSD [Yes(1) or No(0)]		0		0		0		1		1		1	
Statewide I/M Vehicles with Complete Data for the Selection Method (%)		100%		100%		100%		16.97%		100%		100%	
Capital Costs													
DMV for Programming, form changes, etc.. (One-time Fee for Calling-In Program)			$500,000		$500,000		$500,000		$500,000		$500,000		$500,000
Central Office Computer Equipment ($20K for server + $2K per person)			$95,000		$95,000		$95,000		$55,484		$97,000		$97,000
Other Capital Costs - central office supplies and equipment			$101,081		$101,081		$101,081		$47,823		$103,777		$103,777
Annual O&M Costs													
Amortized capital costs for DMV for Programming, etc.. (10yrs @10%)			**$81,373**		**$81,373**		**$81,373**		**$81,373**		**$81,373**		**$81,373**
Amortized capital costs for computer equipment (5yrs @10%)			**$25,061**		**$25,061**		**$25,061**		**$14,636**		**$25,588**		**$25,588**
Amortized capital costs for office supplies/equipment (10yrs @10%)			**$16,451**		**$16,451**		**$16,451**		**$7,783**		**$16,889**		**$16,889**
Labor for Central Office													
Position	Annual Salary @ 40hrs/wk												
Program Administrator	$90,970	1.00	$90,970	1.00	$90,970	1.00	$90,970	1.00	$90,970	1.00	$90,970	1.00	$90,970
Program Manager	$70,754	2.50	$176,885	2.50	$176,885	2.50	$176,885	3.00	$212,262	3.00	$212,262	3.00	$212,262
Engineer /Data Analyst/Programmer	$70,754	4.50	$318,393	4.50	$318,393	4.50	$318,393	5.00	$353,770	5.00	$353,770	5.00	$353,770
Attorney	$63,000	3.00	$189,000	3.00	$189,000	3.00	$189,000	1.34	$84,379	3.00	$189,000	3.00	$189,000
Public Information/Communication	$30,323	20.00	$606,460	20.00	$606,460	20.00	$606,460	4.22	$128,079	20.00	$606,460	20.00	$606,460
Administrative Assistant	$48,000	1.00	$48,000	1.00	$48,000	1.00	$48,000	1.00	$48,000	1.00	$48,000	1.00	$48,000
Receptionist	$30,323	1.00	$30,323	1.00	$30,323	1.00	$30,323	1.00	$30,323	1.00	$30,323	1.00	$30,323
Clerical and Secretarial Staff	$30,323	4.50	$136,454	4.50	$136,454	4.50	$136,454	1.18	$35,742	4.50	$136,454	4.50	$136,454
Salary * Person-Years		37.5	$1,596,485	37.5	$1,596,485	37.5	$1,596,485	17.74	$983,524	38.5	$1,667,239	38.5	$1,667,239
Overhead and Fringe (100%)			$1,596,485		$1,596,485		$1,596,485		$983,524		$1,667,239		$1,667,239
Equipment maintenance (@20%)			$20,216		$20,216		$20,216		$9,565		$20,755		$20,755
Supplies (@10% of Maintenance)			$2,022		$2,022		$2,022		$956		$2,076		$2,076
Total Labor for Central Office, fully burdened			**$3,215,207**		**$3,215,207**		**$3,215,207**		**$1,977,570**		**$3,357,308**		**$3,357,308**
Misc. Recurring Costs, Central Office													
Operating supplies ($250/person-yr)			$9,375		$9,375		$9,375		$4,435		$9,625		$9,625
Travel ($250/person-yr)			$9,375		$9,375		$9,375		$4,435		$9,625		$9,625
Hiring and training costs			$17,955		$17,955		$17,955		$8,495		$18,434		$18,434
Total for misc. recurring costs at central office			**$36,705**		**$36,705**		**$36,705**		**$17,366**		**$37,684**		**$37,684**
Other Contract Support (2% of program expenses)			**$67,496**		**$67,496**		**$67,496**		**$41,975**		**$70,377**		**$70,377**
Total Annual CENTRAL OFFICE O&M Costs (including capital recovery)			**$3,442,292**		**$3,442,292**		**$3,442,292**		**$2,140,702**		**$3,589,219**		**$3,589,219**

D = Directing, X = Exempting, C = Calling-In, S = Scrapping
/proj1/DecisionModel/Report/IM_Strategy_Evaluator_070323.xls

- **Engineer/Data Analyst/Programmer** – These personnel are responsible for weekly acquisition of the registration, VID, RSD, and notice history data. They put the data on the server and run the vehicle ranking and targeting software to produce weekly lists of vehicles to be targeted for Calling-In, Directing, Exempting, and Scrapping. They are also responsible for quality checking the data before and after each weekly run and ensuring that the lists reach their destination for notices to be sent. Because this work must be completed each week, enough personnel must be available to prevent getting behind.

- **Public Information Specialist/Attorney** – These personnel are responsible for handling the public as it responds and inquires about the special strategies. When the special strategies include only Directing, Exempting, or Scrapping, the demand for these personnel will be low. However, when Calling-In is part of the special strategy package, we anticipate that many vehicle owners will be contacting the central office with questions and/or complaints. In this situation, the number of these personnel must be large enough to handle the workload. These personnel will also handle public outreach and education.

- **Administration Assistant/Clerk/Secretary/Receptionist** – The number of these personnel is, in general, proportional to the size of the program. Even the smallest program will require a Secretary/Receptionist. Larger programs will require additional personnel of this type as the need for communication with the public and with other agencies increases.

Table 5-4 shows the sum of the salaries for these personnel and costs for loading the salaries with overhead and fringe benefits, equipment maintenance, and supplies. This produces a total labor cost for the central office that is fully burdened. The table then shows miscellaneous recurring costs for the central office for operating supplies, travel, and hiring and training costs. These costs are based on the number of personnel at the central office. Finally, the last item is an expense for other contract support, which is estimated to be 2% of the other central office costs. The last row in the table gives the total annual central office costs for the different descriptions of central offices.

5.3 Estimates of Scrappage Vehicle Purchase Cost

For the Scrappage strategy, the state buys vehicles and destroys them as a means of eliminating the emissions of those vehicles from the inventory. Of the four strategies evaluated in this study, Scrapping is the only strategy in which vehicles are purchased. Therefore, the purchase cost of these vehicles is a cost only for Scrapping and not for Directing, Exempting, or Calling-In.

Another important difference between Scrapping and the other strategies is the approach used to calculate the benefits and costs for the strategy. For Directing, Exempting, and Calling-In, we select the fleet penetration that we want to evaluate and then we calculate the benefits that we would get and the costs that would be incurred for targeting that fraction of the I/M fleet. However, selecting the penetration for Scrapping is different. In recent years, California has allocated a set amount of money to spend for the purchase of vehicles for Scrapping. The size of this fund determines the penetration that will be needed to target vehicles for scrappage each year. Once the penetration is determined, then we can calculate the benefits and the other, non-vehicle-purchase costs incurred. We have used this approach for calculating the benefits and costs for the large RSD program described in this report.

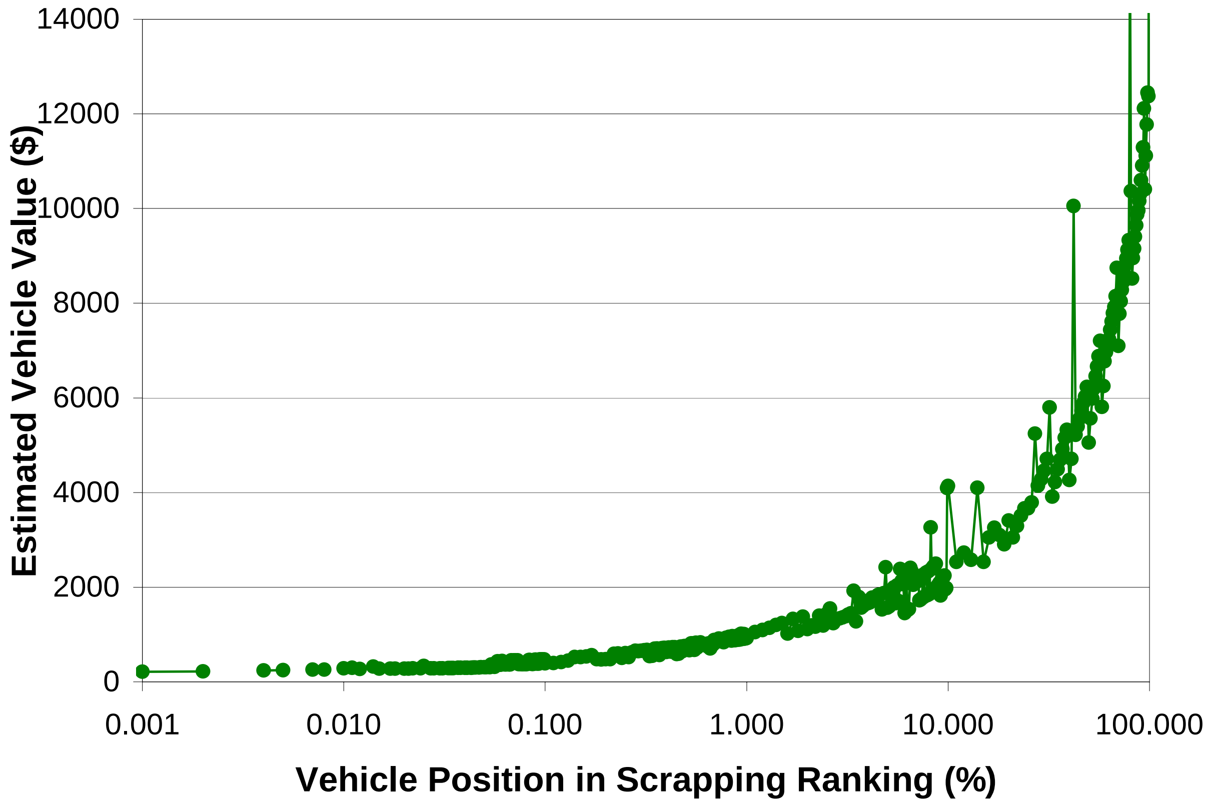
To estimate the purchase cost of vehicles that are targeted for Scrapping, we need to be able to estimate the purchase cost of each individual vehicle. Since potentially any Scrapping penetration needs to be able to be evaluated, we have chosen to estimate the purchase cost of individual vehicles based on an estimate of the value of the individual vehicles. We use the same vehicle value estimating functions, which are based on vehicle make, vehicle type, and vehicle age, as were described in the modeling report. [1]

We recognize that in the past, California has offered a fixed amount to purchase vehicles from owners. By using estimated vehicle value to estimate the purchase cost of a set of targeted vehicles, we are not necessarily advocating that the state negotiate with owners for vehicle purchases. Rather, we believe that using the estimated vehicle value serves as a lower limit on the amount of money that would be needed to purchase the targeted scrappage vehicles; clearly, vehicle owners would not be likely to accept a purchase offer made for an amount that is less than the value of the vehicle. On the contrary, we would expect that vehicle owners would want the state to pay them a premium on top of the value of their vehicle. Consequently, we expect that the state would be able to purchase fewer vehicles than we estimate by the calculations in this study. As a result, our estimates of scrappage vehicle purchase costs will produce higher estimates of emissions reductions than would actually be achieved. The method of estimating scrappage vehicle purchase costs that we are using will err on the side of making the scrappage strategy appear more cost-effective than it will actually turn out to be. Nevertheless, the method that we use for estimating scrappage vehicle purchase cost is consistent across all vehicles in the fleet regardless of their age. In addition, the approach recognizes the influence of market forces in determining whether a vehicle owner will accept the state's scrappage offer or reject it.

We will demonstrate the calculation of scrappage vehicle purchase cost by considering a vehicle ranking using the ranking variable FprobDP/$ by A. This ranking method was found in the modeling report to select vehicles for scrappage with the highest efficiency as measured by mass of HC+NX emissions reduced per dollar of vehicle value. This vehicle ranking variable uses only model year and the estimated value of the vehicle as defined by vehicle make and vehicle type to rank the vehicles for Scrapping.

Figure 5-2 shows a plot of the estimated vehicle value for the individual 69,629 vehicles in the modeling dataset as a function of the Vehicle Position in the Scrapping Ranking by FprobDP/$ by A. Vehicles with the smallest vehicle position are the top candidates for Scrapping. In the figure, we have used a logarithmic scale for the vehicle position since the vehicles that are likely to be scrapped are those in the top 1% of the ranking. The figure shows that vehicles that are ranked highest for Scrapping have low estimated vehicle values of around $250. The vehicles that are ranked lowest for Scrapping have high estimated vehicle values. In fact, the highest estimated vehicle value point which occurs for a vehicle position of 100% is off the vertical scale of the graph but has a value of $30,030. Those are clearly quite new vehicles.

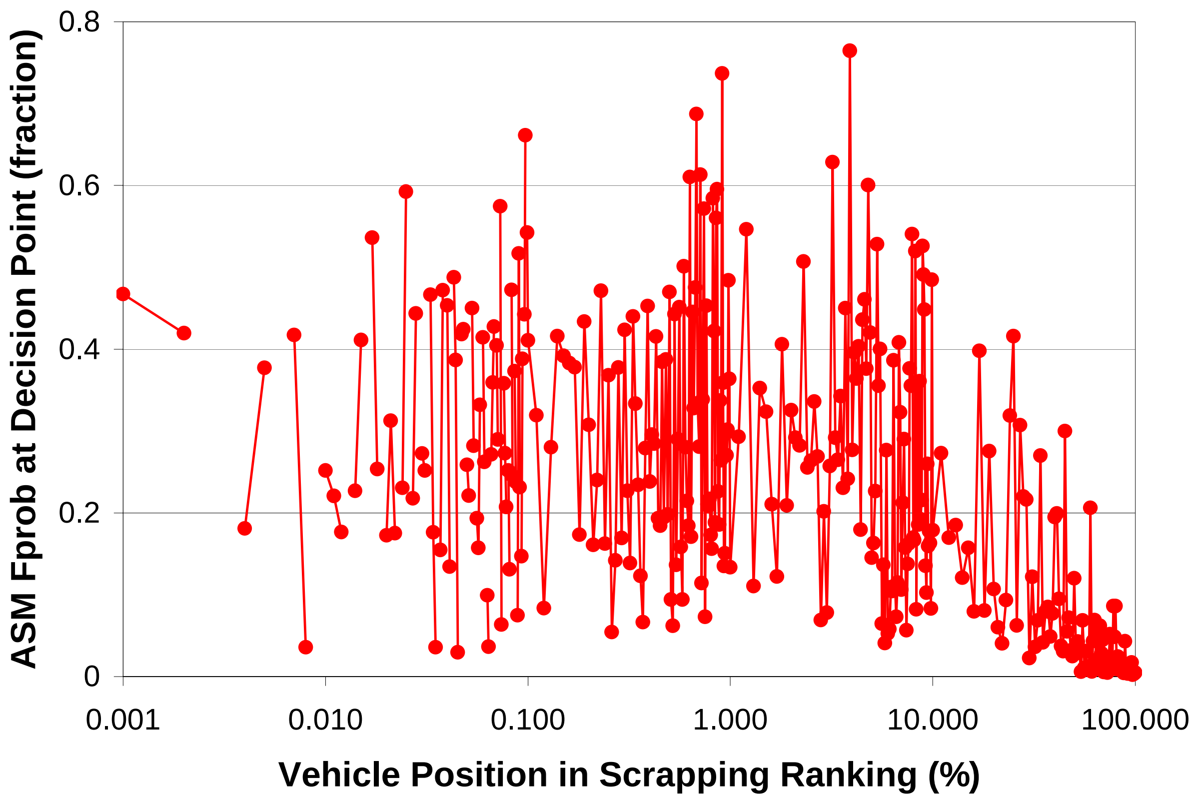
Figure 5-2. Vehicle Value vs. Scrapping Ranking by FprobDP/$ by A



/c:/MyDocuments/CA RSD Pilot Decision report/Implementation report/Scrappage Purchase Cost.xls

To estimate the size of the state's vehicle scrappage expenditure, we need to consider more than the value of each vehicle. In a scrappage program, the state will not purchase every vehicle that is called in for a scrappage ASM. It will only purchase those vehicles that fail the scrappage ASM. Therefore, we need to consider the probability of ASM failure for each of the individual vehicles in the dataset at the time of a scrappage ASM. These overall ASM failure probabilities for the 69,629-vehicle dataset are shown in Figure 5-3. All of these failure probabilities are estimated using the Model D Fprob model, which uses VID history and RSD readings as inputs. As in other parts of this study, we assume that the true failure probabilities of the vehicles are equal to the Fprobs calculated using Model D. The figure shows that the ASM Fprobs are around 0.3 for the top 10% of the vehicle rankings. For vehicles that are in the bottom 90% of the Scrapping ranking, the ASM Fprobs drop until they are quite low for the vehicles that are at the bottom of the Scrapping ranking, which is at 100%.

Figure 5-3. Overall ASM Failure Probability by Model D vs. Scrapping Ranking by FprobDP/$ by A



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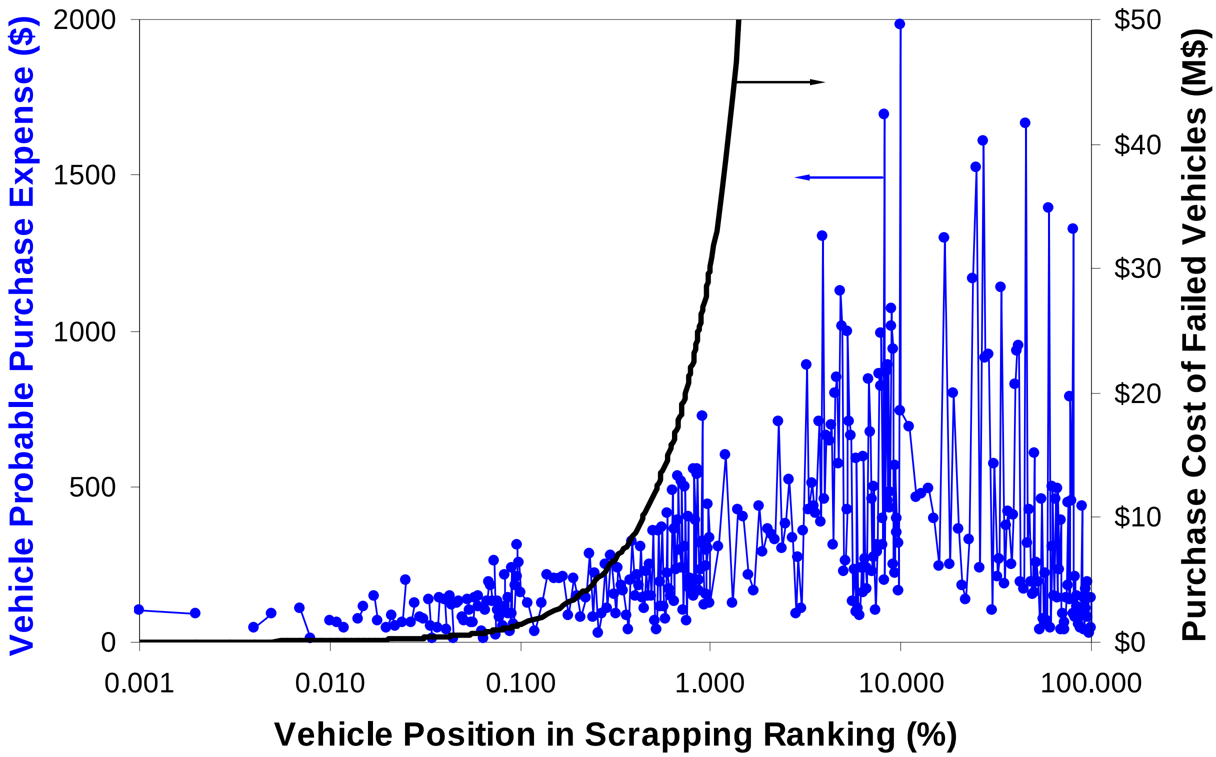
The exposure of the state to purchase an individual vehicle for scrappage is the product of its ASM failure probability and its estimated vehicle value. We call this quantity the Vehicle Probable Purchase Expense. We cannot predict with certainty which vehicles will fail the scrappage ASM test; however, we can calculate the probability that a vehicle will fail. The sum of the vehicle values of the vehicles that fail the scrappage ASM test will be close to the sum of the products of the probability of failure and the vehicle value for each tested vehicle. For example, suppose 100 vehicles were candidates for scrappage, each of the vehicles had an ASM failure probability of 20%, and each of the vehicles had a vehicle value of $500. The total expense to the state can be estimated before the vehicles are called in and before the scrappage ASM tests are performed. The vehicle probable purchase expense for each vehicle would be $100 (= 20% of $500) and, therefore, the anticipated purchase cost of the failed vehicles would be $10,000 (= 100 * $100). Based on the ASM failure probability, we would expect that 20 of the vehicles (= 20% of 100) would fail the scrappage ASM test. It would cost the state $10,000 (= 20 * $500) to purchase those vehicles. This is the same value of total expense that was estimated before the scrappage ASM tests were performed.

The blue curve with the circle symbols in Figure 5-4 shows the vehicle probable purchase expense for the 69,629-vehicle dataset. On the left side of the plot, the vehicle probable purchase expense is near $100. These values are for vehicles that have values around $250 and whose Fprobs are approximately 40% (40% * $250 = $100). On the right side of the plot near 100% Scrapping ranking, vehicles also have probable purchases expense values near $100. However, these are high-valued vehicles around $20,000 that have failure probabilities of approximately 0.5% (0.5% * $20,000 = $100). The maximum in the figure for the vehicle probable purchase expense is in the vicinity of 10% Scrapping ranking. These vehicles typically have values, as can be seen from Figure 5-2, of around $3,000 but their failure probabilities are still relatively high at around 25%. Overall, the vehicle probable purchase expense on the left side of Figure 5-4 is dominated by the low vehicle value, on the right side of Figure 5-4 it is dominated by the low failure probability. In the middle of the ranking, the vehicle probable purchase expense is dominated by neither vehicle value nor low failure probability and as a consequence it is higher there.

Figure 5-4. Vehicle Probable Purchase Expense vs. Scrapping Ranking by FprobDP/$ by A



/c:/MyDocuments/CA RSD Pilot Decision report/Implementation report/Scrappage Purchase Cost.xls

When the state selects vehicles to call in for scrappage ASM tests, it is selecting vehicles whose probable purchase expenses are represented by data points on the left side of Figure 5-4. How far down the Scrapping ranking the state wants to go depends on the size of the fund set aside to purchase vehicles for Scrapping. To determine how far down the Scrapping ranking the state would need to go to spend the funds, we have shown the cumulative of the vehicle probable purchase expenses of vehicles from the top of the Scrapping ranking in Figure 5-4 as the solid thick black curve. The right axis in Figure 5-4 expresses the cumulative costs in millions of dollars as the purchase cost of the vehicles that would fail the scrappage ASM. We have calculated these purchase costs by scaling up the number of vehicles that would fail in the 69,629-vehicle modeling set to the 13,388,069-vehicle statewide I/M fleet. Thus, the black curve can be used to determine the fraction of the fleet that should be targeted when vehicles are ranked by Fprob DP/$ by A to fit a given scrappage vehicle purchase budget. For example, if the state had a biennial purchase budget of $16 million, Figure 5-4 indicates that approximately the top 0.62% of the vehicles ranked using FprobDP/$ by A should be targeted for a scrappage ASM test. Note that this targeting percentage takes into account the ASM failure probability and the market value of the individual vehicles in the fleet.

5.4 Estimates of Vehicle Repair Costs

When intervention strategies such as Directing, Exempting, Calling-In, and Scrapping are applied to the existing California I/M program, changes to the repair costs of individual vehicles that had been in the Normal I/M Process will occur. In the modeling report [1], we developed a method to quantify the size of these incremental repair cost changes by considering the size of the repair costs for the two paths under consideration for an individual vehicle: the Normal I/M Process path and the intervention strategy path. In that report, the failure probability models and the I/M completion probabilities were used to forecast probable repair costs for individual vehicles for the different strategy decision choices: Directing, Exempting, Calling-In No-Sticker, Calling-In Sticker, Scrapping, and the Normal I/M Process.

In the modeling report we used a particular type of vehicle, Ford Tauruses with a 3.0L V6 engine, to demonstrate how we calculate repair costs for the different I/M strategy paths. We "configured" the vehicle with different VID history and RSD measurement characteristics so that the calculations would simulate a probable low emitter and a probable high emitter. The probable low emitter was simulated by setting the previous-cycle ASM results to all passes and the recent RSD measurements to the lowest possible concentration values. The probable high emitter was simulated by setting the previous-cycle ASM results to fail for ASM2525 NX and other ASM results to pass and the recent RSD measurements to low values for HC and CO but the RSD NX measurement to 7,800 ppm.

The low emitter configuration was used to estimate the repair costs for Exempting in comparison with the Normal I/M Process. The higher emitter configuration was used to examine the repair costs for Directing, Calling-In No-Sticker, and Scrapping in comparison with the Normal I/M Process.

Table 5-5 shows a summary of the probable repair cost results from those calculations. The probable repair costs were calculated for the 48 months following the decision point, which is the date on which the decision is made to assign the vehicle to a special strategy or to let it remain in the Normal I/M Process.

Table 5-5. Probable Repair Costs Over 48 Months After the Decision Point for the Example Vehicle Description

Vehicle Emissions Characteristic	Intervention Strategy				
	Normal I/M Process	Exempting	Directing	Calling-In No-Sticker	Scrapping
Probable Low Emitter	$7.78	$10.54	-	-	-
Probable High Emitter	$98.32	-	$117.98	$140.80	$32.85

The table shows that the repair costs incurred by Exempting the probable low emitter are higher than if the probable low emitter is left in the Normal I/M Process. The increased repair cost is caused by the increase in probability of a repair being needed because the inspection is delayed two years. Vehicles that are exempted are those that have a low, but not a zero, failure probability. When we exempt them, we suspect that they are low emitters, but we do not know they are low emitters since no ASM test is done. Whether the exempted vehicles are low emitters or a few are high emitters does not really matter because the failure probability of all emitters tends to go up with time. Two years after the exemptions, the failure probability of all exempted vehicles will be higher. Therefore, the expected repair costs two years after the exemption will be higher than the expected repair costs at the time of the exemption.

In the case of Directing, which, like Exempting, occurs at the regularly scheduled biennial date, probable repair costs are higher than the corresponding repair cost for leaving the vehicle in the Normal I/M Process. This increase is due to the increased likelihood that a directed vehicle will fail the ASM test at a high-performing station than at an average-performing station.

The table shows that in the case of Calling-In No-Sticker, the probable repair costs are also higher than the repair cost for leaving the vehicle in the Normal I/M Process. A portion of the increased repair cost is due to the call-in ASM test, which is an “extra” ASM test that the vehicle would not undergo if it remained in the Normal I/M Process. The repair cost calculations also indicated that even if the vehicle received this additional ASM test and potentially needed a repair, because the vehicle was a high emitter, it would have a higher tendency to need an additional repair at the regular ASM inspection in comparison with a low emitter.

In the case of Scrapping, the probable repair cost for a probable high emitter was lower than the repair cost if the vehicle remained in the Normal I/M Process – but the repair cost was not zero. Of course, the future repair cost for vehicles that fail the scrappage ASM test would be zero – because those vehicles would be scrapped. However, there is always a probability that the probable high emitter would pass the scrappage ASM test and, therefore, continue in the I/M program. It would thereby incur future repair costs. However, our calculations also took into account that the vehicles that passed the scrappage ASM test would be less likely to need repairs in the future and, therefore, the repair costs for the scrappage ASM passing vehicles would be lower than for all vehicles of the same age.

Those results from the modeling report were for particular configurations of vehicles that had the Ford Taurus description. To estimate the probable repair costs of the California I/M fleet we needed to generalize those results so that they would be representative of the incremental repair costs as a whole when portions of the fleet would take the Exempting, Directing, Calling-In, or Scrapping path instead of the Normal I/M Process path. We knew how to perform the calculations for repair costs at the same level of detail that was used to calculate the benefits of the special strategies. However, project budget and schedule constraints forced us to take the following alternate route to approximate the incremental repair costs of the special strategies. As it turns out, the overall cost and cost-effectiveness of the special strategies is not very sensitive to small errors in the estimation of the incremental repair costs.

We developed a dedicated simulator to provide detailed cost and benefit results for the Ford Taurus 3.0L vehicle as a function of RSD measurements and VID history. We made numerous runs of this simulator to determine how the incremental repair costs change for different configurations of low emitter, high emitter, and time since the previous I/M cycle. After performing numerous simulation calculations, we selected repair cost adjustment factors for each of the different special strategies that generalize the effect of the strategy on the change in repair cost. These repair cost adjustment factors are shown in Table 5-6. They indicate that the probable repair costs for Exempting, Directing, Calling-In No-Sticker, and Scrapping are 45% above, 20% above, 70% above, and 75% below the probable repair costs for the Normal I/M Process. We will leave the more detailed calculation of incremental repair costs for the I/M fleet for the special strategies to future work.

Table 5-6. Repair Cost Adjustment Factors

Repair Cost Adjustment Factor	Intervention Strategy			
	Exempting	Directing	Calling-In No-Sticker	Scrapping
	+45%	+20%	+70%	-75%

5.5 Estimates of Other Unit Costs

We arrived at unit cost estimates for the various other cost items required for operating and otherwise administering the various intervention strategies. The unit cost estimates are summarized in Table 5-7. The unit costs for all of these items, except for scrappage and model maintenance, are based on communications with BAR.

Table 5-7. Estimated Unit Costs for Other Cost Items

Cost Item ($-basis)	Estimate	Notes and Source
Model update and maintenance ($/yr)	$200,000	Estimate by ERG. Independent of type of model.
Notices ($/notice mailed)	$3	BAR
Inspect ($/vehicle)	$50	BAR
Certificate ($/vehicle)	$8.25	BAR
Repair ($/repair)	$194	BAR

The situations in which the unit costs presented in Table 5-7 represent incremental costs with respect to the base case scenario are discussed in the next section.

5.6 Application of Unit Costs to Intervention Activities

We want to calculate the cost-effectiveness of adding the intervention activities described in this study (Directing, Exempting, Calling-In, and Scrapping) to the I/M program. To clearly calculate the incremental costs and benefits of these intervention activities, we need to define the base case I/M program. The I/M program currently operates with an activity that directs HEP and gross polluter vehicles to test-only stations. The key goal of the current project is to estimate the costs and benefits of using RSD over other methods as part of the intervention activities. This study did not estimate the costs and benefits of the existing Directing activity. Therefore, we will define the base case I/M program to be used for the evaluation as not having the current Directing activity. Such an assumption leads to proper accounting for both costs and benefits of the Directing activity and allows us to compare the various models or approaches on equal footing.

The primary purpose of the base case I/M scenario is to have a defined level from which to compare the models developed under this project. So, we define the base case I/M program as the current I/M program but without any intervention activities for Directing, Exempting, Calling-In, or Scrapping. The base case does include exempting the newest six model years since this is an eligibility policy rather than an activity that intervenes in the Normal I/M Process.

A previous subsection estimated the cost of different items that would be used when supplementing the base case I/M program with intervention activities. However, not every intervention activity will use every one of these items. In some cases, items that are required for a particular type of intervention activity are already being paid for in the normal process of the base case I/M program scenario. In this subsection, we consider each intervention activity and each cost item so that the costs for each intervention activity can be calculated. Table 5-8 shows where different cost items are applied.

Table 5-8. Cost Changes Relative to the Normal I/M Process Caused by Intervention Activities

Cost Item	Unit Cost	Intervention Activity			
		Calling-In No-Sticker	Directing	Exempting	Scrapping
Central Office	No unit cost	Calculated as a function of the scope of the intervention activities.			
RSD Measurement	$0.50 to $1.00[a]	Cost per valid RSD measurement, matched to registration records			
Notice	$3.00	+$3/notice	None	None	+$3/notice
Certificate	$8.25	None	None	None	-$8.25/targeted vehicles that fail
Inspection	$50	+$50/targeted vehicle	None	-$50/targeted vehicle	+$50/targeted vehicle
Repair	$194	+70% * $194 per targeted vehicle that would have failed in the Normal I/M Process	+20% * $194 per targeted vehicle that would have failed in the Normal I/M Process	+45% * $194 per targeted vehicle that would have failed in the Normal I/M Process	-75% * $194 per targeted vehicle that would have failed in the Normal I/M Process

[a] Depends on RSD program design. See Figure 5-1.

Central Office –The Central Office cost is a function of many factors including the strategies selected, the penetration for each strategy, whether RSD is used or not, the fleet coverage of the RSD measurement program, and the vehicle ranking method that is used. These program features determine the amount of staff, equipment, supplies, and contract support needed to run the program. A description of the costs is provided in Section 5.2.

RSD Measurements – The cost of RSD measurements is proportional to the number of valid, matched RSD values that are obtained. Because RSD values can be used to rank vehicles for Directing, Exempting, Calling-In, or Scrapping, adding additional intervention activities does not cause the cost of RSD measurements in a geographical area to increase. However, the RSD data collection unit cost is a function of RSD coverage as described in Section 5.1.

Notices – In the base case I/M program scenario, notices are sent to all owners to remind them that their inspection date is approaching. Since owners can be directed and exempted by making changes to the wording of the reminder letter, there are no incremental notice costs for Directing and Exempting. On the other hand, Calling-In and Scrapping are off-cycle activities in this analysis. Therefore, special notices, which cause incremental notice costs, need to be sent out. The cost for notices is the same whether RSD is used or not.

Certificates – The incremental costs for certificates vary for the different intervention activities. In the case of Directing, directed vehicles are tested at high-performing stations rather than average-performing stations. However, in both cases, the same number of certificates would be issued. In the case of Exempting, exempted vehicles would still be required to get new certificates even though they did not receive an inspection. In the case of Calling-In No-Sticker, vehicles that are called in would not receive a new certification, which represents no change beyond the base case I/M program scenario. In the case of Scrapping, vehicles that passed the scrappage ASM test would not be given a new certification, but would be required to continue following the requirements of their existing certification. Vehicles that failed the scrappage ASM test would not be required to get a new certification since those vehicles would be scrapped. Since they are removed from the fleet, the absence of future required certifications is a credit.

Inspections – For incremental inspections beyond the base case scenario, the situation is different for the different intervention activities. For Directing, the same number of inspections would be performed whether the vehicles were tested at high-performing stations or at average-performing stations. Accordingly, there is no incremental cost for inspections for Directing[6]. In the cases of Calling-In and Scrapping, the call-in and scrappage ASM tests are in addition to the base case I/M program scenario. Accordingly, incremental costs for call-in and scrappage inspections are incurred. In the case of Exempting, no vehicles that would be exempted would receive an ASM test. The large cost credit associated with this large decrease in the number of inspections performed is the major incentive for exempting vehicles.

[6] We are assuming that the average costs for repairs resulting from failures at average-performing and high-performing stations are the same.

Repairs – For each of the different strategies the change in repair cost is based on the number of vehicles that would have failed in the Normal I/M Process. To get the change in repair cost, the unit repair cost of $194 is multiplied by the repair cost adjustment factor from Table 5-6 for the corresponding strategy and multiplied by the number of targeted vehicles that would have failed if they remained in the Normal I/M Process.

5.7 Biennial Incremental Costs for Full-Fleet Ranking Methods

In the previous two subsections, the unit costs for RSD and non-RSD items and the conditions under which they should be applied were presented. In this section, those cost items are combined with the biennial estimates of targeted vehicles and failing vehicles to arrive at the total biennial incremental cost and the cost components for each of the four intervention activities and for each of the six full-fleet ranking methods. Table 5-9 shows the results of these calculations. The table is broken down into the eight cost items: central office, RSD measurement, notices, certificates, inspections, repairs, vehicle purchases, and model update and maintenance. For each of these items, the table indicates the total cost for each intervention activity as a function of the six full-fleet ranking methods that are used in the study. The table also indicates, where applicable, the unit cost and the incremental cost for each cost item in $/2years.

In Table 5-9, positive costs represent expenditures and negative costs represent credits. For example, the cost for central office, RSD measurement, notices, vehicle purchases, and model update and maintenance are all expenditures. The cost for certificates during Scrapping is a credit since fewer certificates will need to be issued when vehicles are scrapped. For inspections in the Exempting activity, we see credits. This arises because of the large number of exempted vehicles that are exempted from receiving an inspection. Credits also occur for repairs that are not performed for scrapped vehicles.

Table 5-9. Biennial Incremental Costs for Full-Fleet Ranking Methods

Cost Item	Full -Fleet Ranking Method Description	Intervention Activity			
		Calling-In No-Sticker	Directing	Exempting	Scrapping
Central Office					
Incremental Cost ($/2years)	**Model Year**	$6,884,584			
	Vehicle Description	$6,884,584			
	VID History	$6,884,584			
	RSD + Nothing	$4,281,405			
	RSD + VID History	$7,178,438			
	VID/RSD + VID History	$7,178,438			
RSD Measurements					
Valid, DMV-Matched RSDs per year for a 5 AQMD any-VSP RSD coverage of:	50%	31,638,132			
Unit Cost ($/ valid, DMV-matched RSD measurement)		$1.00			
Incremental Cost ($/2years)	**Model Year**	$0			
	Vehicle Description	$0			
	VID History	$0			
	RSD + Nothing	$63,276,265			
	RSD + VID History	$63,276,265			
	VID/RSD + VID History	$63,276,265			
Notice					
Unit Cost ($/ notice mailed)		$3	$0	$0	$3
Incremental Cost ($/2years)	**Model Year**	$2,008,210	$0	$0	$249,018
	Vehicle Description	$2,008,210	$0	$0	$192,788
	VID History	$2,008,210	$0	$0	$176,723
	RSD + Nothing	$340,742	$0	$0	$95,408
	RSD + VID History	$2,008,210	$0	$0	$172,706
	VID/RSD + VID History	$2,008,210	$0	$0	$168,690
Certificate					
Unit Cost ($/ targeted vehicle that fails)		$0	$0	$0	($8.25)
Incremental Cost ($/2years)	**Model Year**	$0	$0	$0	($216,004)
	Vehicle Description	$0	$0	$0	($195,610)
	VID History	$0	$0	$0	($189,220)
	RSD + Nothing	$0	$0	$0	($118,670)
	RSD + VID History	$0	$0	$0	($190,105)
	VID/RSD + VID History	$0	$0	$0	($188,261)

Table 5-9. (continued)

Cost Item	Full -Fleet Ranking Method Description	Intervention Activity			
		Calling-In No-Sticker	Directing	Exempting	Scrapping
Inspection					
Unit Cost ($/ targeted vehicle)		$50	$0	($50)	$50
Incremental Cost ($/2years)	**Model Year**	$33,470,173	$0	($83,006,028)	$4,150,301
	Vehicle Description	$33,470,173	$0	($83,006,028)	$3,213,137
	VID History	$33,470,173	$0	($83,006,028)	$2,945,375
	RSD + Nothing	$5,679,033	$0	($14,084,001)	$1,590,129
	RSD + VID History	$33,470,173	$0	($83,006,028)	$2,878,435
	VID/RSD + VID History	$33,470,173	$0	($83,006,028)	$2,811,494
Repair					
Adjustment Factor (Extra Cost of Strategy beyond NIM and relative to the Unit Repair Cost)		**0.70**	**0.20**	**0.45**	**-0.75**
Unit Cost ($/repair)		$194	$194	$194	$194
Incremental Cost ($/2years)	**Model Year**	$26,644,611	$24,392,479	$2,430,309	($3,809,524)
	Vehicle Description	$31,466,136	$25,956,630	$1,434,738	($3,449,857)
	VID History	$30,152,846	$22,325,603	$5,095,806	($3,337,149)
	RSD + Nothing	$6,715,313	$4,482,830	$345,963	($2,092,905)
	RSD + VID History	$31,751,992	$23,020,348	$4,577,141	($3,352,768)
	VID/RSD + VID History	$31,200,589	$22,939,542	$4,725,082	($3,320,241)
Vehicle Purchases					
Incremental Cost ($/2years)	**Model Year**	$0	$0	$0	$15,642,628
	Vehicle Description	$0	$0	$0	$15,624,309
	VID History	$0	$0	$0	$15,672,716
	RSD + Nothing	$0	$0	$0	$15,142,381
	RSD + VID History	$0	$0	$0	$15,667,580
	VID/RSD + VID History	$0	$0	$0	$15,774,574
Model Update & Maintenance					
Unit Cost ($/year)		$200,000			
Incremental Cost ($/2years)	**Model Year**	$0			
	Vehicle Description	$400,000			
	VID History	$400,000			
	RSD + Nothing	$400,000			
	RSD + VID History	$400,000			
	VID/RSD + VID History	$400,000			

6.0 Cost-Effectiveness Results

This final section combines the benefits and costs calculated in previous sections. The overall results are presented in a single table that displays the benefits, the costs, and the cost-effectiveness for any package of special strategies for the six different full-fleet vehicle ranking methods.

All of the calculations in the analysis assume 100% participation of the vehicles that are targeted. We know that in the real world 100% participation may not be achieved. The actual participation rates will depend on human behavior and on policy decisions and the systems put in place to manage the strategies. If the actual participation is far from 100%, the estimated benefits, costs, and cost-effectiveness of these calculations will not represent what the I/M program will experience. In general, we expect that participation for Exempting will be high and Directing will be near 100%. However, for Calling-In and Scrapping, where owners must come in for a special off-cycle ASM test, we expect lower participation rates. Owner response to a request for owners to bring vehicles in for an off-cycle call-in or scrappage ASM test is likely to depend on how strong the request is and if it is backed up by enforcement or not. In addition, for Scrapping, owners must decide if they will sell their vehicles to the state before they can be considered participants. An owner's decision is likely to depend on the size of the offer relative to their perceived value of the vehicle.

The participation rates will affect benefits. Clearly, if participation is 0%, no benefits will be realized. Lower participation can also reduce costs. However, if RSD is needed to select vehicles for special strategies, the full cost of RSD data collection is incurred even if participation is 0%. If we consider Calling-In, lower participation would reduce costs for inspections and repairs, but lower participation would not reduce costs for RSD data collection and notices, and it would likely increase central office costs substantially as the staff attempts to get owners to bring their vehicles in for a call-in ASM test. If we consider Scrapping, lower participation at bringing vehicles in for the scrappage ASM test would reduce costs for inspections, but lower participation would not reduce costs for RSD data collection and notices. If Scrapping candidates came in and received a failing ASM test but did not accept the state's purchase offer, only the vehicle purchase cost would be reduced.

The cost-effectiveness calculations could easily be modified to demonstrate the influence of lower than 100% participation on the results, but we have not done this in this study. Nevertheless, we can see from the discussion in the previous paragraph that lower participation decreases benefits while decreasing only some of the costs. Thus, lower participation will cause the special strategies to be less cost-effective than presented in the tables of this section. This will be especially the case for Calling-In and Scrapping, where there is significant risk of lower participation. In addition, any vehicle ranking method that requires RSD measurements will be substantially less cost-effective than presented below since a full RSD data collection program is required and since a full RSD data collection program makes up a major part of the special strategy program costs.

In the two subsections below, we demonstrate the overall cost-effectiveness of supplementing the base case I/M program with two different special strategy packages.

6.1 Performance of the Four-Strategy Package

The final summary of costs and benefits for the package of four strategies is presented in Table 6-1. The benefit values were taken from Table 4-7. The cost values were taken from Table 5-9. The columns represent each of the six full-fleet ranking methods used to evaluate the enhancements to the base case I/M program. The first three results columns are for full-fleet ranking methods that do not use RSD. The second three columns are for full-fleet ranking methods that use RSD. However, note that headings of the RSD ranking method columns remind us that this large RSD data collection program provides usable-VSP RSD data on only 16.97% of the statewide I/M fleet, as discussed in Section 3.2. The final column presents the incremental benefit of the RSD technology, which was calculated as the values in the sixth column (VID/RSD + VID History) minus the third column (VID History).

Costs – The top part of the table represents the various costs described in Section 5. All four intervention activities (Calling-In, Directing, Exempting, and Scrapping) are presented in the table. The costs for each aspect of the activity are presented.

The costs for the three different non-RSD ranking methods (in the first three columns) are quite similar to each other. Each of these strategies can cover virtually 100% of the statewide I/M fleet – even those vehicles that are outside of the 5 largest AQMDs. For each of the three non-RSD methods the costs are dominated by a large savings of $83 million associated with the exemption of 20% of the fleet for one biennial inspection. In addition, large expenditures are made for Calling-In inspections, Calling-In repairs, Directing repairs, and Scrapping vehicle purchases. In total, the non-RSD ranking methods have biennial costs from $29 million to $34 million.

Table 6-1. Cost-Effectiveness Summary
for Calling-In, Directing, Exempting, Scrapping

	Full-Fleet Ranking Method						
				RSD [f] 16.97% of statewide I/M fleet	RSD [f] 16.97% of statewide I/M fleet	VID/RSD [d] 16.97% of statewide I/M fleet	
	Model Year [a] 100% of statewide I/M fleet	Vehicle Description [b] 100% of statewide I/M fleet	VID History [c] 100% of statewide I/M fleet	Nothing 83.03% of statewide I/M fleet	VID History [c] 83.03% of statewide I/M fleet	VID History [c] 83.03% of statewide I/M fleet	Incremental Benefit of VID/RSD + VID History over VID History
	without RSD			with RSD			
Cost Items ($/2years) [A]							
Central Office							
5% Calling-In No-Sticker; 40% Directing; 20% Exempting; Scrapping	$6,884,584	$6,884,584	$6,884,584	$4,281,405	$7,178,438	$7,178,438	$293,854
RSD Measurements							
5% Calling-In No-Sticker; 40% Directing; 20% Exempting; Scrapping	$0	$0	$0	$63,276,265	$63,276,265	$63,276,265	$63,276,265
Notice							
5% Calling-In No-Sticker	$2,008,210	$2,008,210	$2,008,210	$340,742	$2,008,210	$2,008,210	$0
40% Directing	$0	$0	$0	$0	$0	$0	$0
20% Exempting	$0	$0	$0	$0	$0	$0	$0
Scrapping	$249,018	$192,788	$176,723	$95,408	$172,706	$168,690	($8,033)
Inspection							
5% Calling-In No-Sticker	$33,470,173	$33,470,173	$33,470,173	$5,679,033	$33,470,173	$33,470,173	$0
40% Directing	$0	$0	$0	$0	$0	$0	$0
20% Exempting	($83,006,028)	($83,006,028)	($83,006,028)	($14,084,001)	($83,006,028)	($83,006,028)	$0
Scrapping	$4,150,301	$3,213,137	$2,945,375	$1,590,129	$2,878,435	$2,811,494	($133,881)
Certificate							
5% Calling-In No-Sticker	$0	$0	$0	$0	$0	$0	$0
40% Directing	$0	$0	$0	$0	$0	$0	$0
20% Exempting	$0	$0	$0	$0	$0	$0	$0
Scrapping	($216,004)	($195,610)	($189,220)	($118,670)	($190,105)	($188,261)	$959
Repair							
5% Calling-In No-Sticker	$26,644,611	$31,466,136	$30,152,846	$6,715,313	$31,751,992	$31,200,589	$1,047,744
40% Directing	$24,392,479	$25,956,630	$22,325,603	$4,482,830	$23,020,348	$22,939,542	$613,939
20% Exempting	$2,430,309	$1,434,738	$5,095,806	$345,963	$4,577,141	$4,725,082	($370,724)
Scrapping	($3,809,524)	($3,449,857)	($3,337,149)	($2,092,905)	($3,352,768)	($3,320,241)	$16,908
Vehicle Purchase							
Fleet Sample Penetration (%)	**0.620**	**0.480**	**0.440**	**1.400**	**0.430**	**0.420**	
Scrapping	$15,642,628	$15,624,309	$15,672,716	$15,142,381	$15,667,580	$15,774,574	$101,858
Model Update & Maintenance							
5% Calling-In No-Sticker; 40% Directing; 20% Exempting; Scrapping	$0	$400,000	$400,000	$400,000	$400,000	$400,000	$0
Total Costs ($/2years) [A]	$28,840,910	$33,999,348	$32,599,772	$86,054,087	$97,852,519	$97,438,659	$64,838,889
ΔFTP (HC+NX tons/2years) out of 605088 total tons/2years							
5% Calling-In No-Sticker	(1,819)	(1,855)	(4,595)	(557)	(4,372)	(4,724)	(129)
40% Directing	(3,876)	(3,897)	(4,339)	(730)	(4,333)	(4,423)	(84)
20% Exempting	3,241	3,942	2,358	529	2,487	2,212	(146)
Scrapping	(3,997)	(3,533)	(3,478)	(2,034)	(3,553)	(3,527)	(49)
Total ΔFTP (HC+NX tons/2years) [B]	(6,451)	(5,343)	(10,053)	(2,793)	(9,772)	(10,461)	**(408)**
Cost Effectiveness ($/ton HC+NX) [C]	(4,471)	(6,363)	(3,243)	(30,811)	(10,014)	(9,314)	**(158,877)**
ΔFMD (miles/2years) out of 30624179635 total FMD/2years							
5% Calling-In No-Sticker	(255,391,460)	(306,632,874)	(972,447,180)	(72,776,491)	(880,224,241)	(995,126,275)	(22,679,095)
40% Directing	(486,496,190)	(538,672,116)	(594,758,300)	(96,525,257)	(590,368,275)	(606,709,974)	(11,951,674)
20% Exempting	200,602,866	133,453,029	143,777,037	26,921,267	146,303,015	122,609,996	(21,167,040)
Scrapping	(179,679,066)	(186,801,268)	(190,210,114)	(133,180,660)	(192,713,478)	(194,587,521)	(4,377,407)
Total ΔFMD (miles/2years) [D]	(720,963,850)	(898,653,230)	(1,613,638,558)	(275,561,141)	(1,517,002,979)	(1,673,813,774)	(60,175,216)

Table 6-1 (Continued)

	Full-Fleet Ranking Method						
	without RSD			with RSD			
	Model Year [a]	Vehicle Description [b]	VID History [c]	RSD [f] 16.97% of statewide I/M fleet	RSD [f] 16.97% of statewide I/M fleet	VID/RSD [d] 16.97% of statewide I/M fleet	Incremental Benefit of VID/RSD + VID History over VID History
	100% of statewide I/M fleet	100% of statewide I/M fleet	100% of statewide I/M fleet	Nothing 83.03% of statewide I/M fleet	VID History [c] 83.03% of statewide I/M fleet	VID History [c] 83.03% of statewide I/M fleet	
Total Number of Targeted Vehicles							
5% Calling-In No-Sticker	669,403	669,403	669,403	113,581	669,403	669,403	0
40% Directing	5,355,228	5,355,228	5,355,228	908,645	5,355,228	5,355,228	0
20% Exempting	2,677,614	2,677,614	2,677,614	454,323	2,677,614	2,677,614	0
Scrapping	83,006	64,263	58,908	31,803	57,569	56,230	(2,678)
Targeted Vehicles That Would Fail an ASM at the Decision Point							
5% Calling-In No-Sticker	196,205	231,709	222,039	49,450	233,814	229,754	7,715
40% Directing [E]	125,734	133,797	115,080	23,107	118,662	118,245	3,165
20% Exempting	27,839	16,435	58,371	3,963	52,430	54,125	(4,247)
Scrapping	26,182	23,710	22,936	14,384	23,043	22,820	(116)
Fraction of Targeted Vehicles That Would Fail an ASM at the Decision Point							
5% Calling-In No-Sticker	0.29	0.35	0.33	0.44	0.35	0.34	
40% Directing [E]	0.023	0.025	0.021	0.025	0.022	0.022	
20% Exempting	0.010	0.006	0.022	0.009	0.020	0.020	
Scrapping	0.32	0.37	0.39	0.45	0.40	0.41	
Average Value of Vehicles Targeted for Scrapping	$597	$659	$683	$1,053	$680	$691	

Footnotes

[A] Negative Costs means saving money, Positive Costs means spending money.
[B] Negative ΔFTP means emissions decrease, Positive ΔFTP means emissions increase.
[C] Interpret cost effectiveness value in terms of Total Costs and Total ΔFTP.
[D] Negative ΔFMD means decrease in total Failed Miles Driven, Positive ΔFMD means increase in total Failed Miles Driven.
[E] The number of directed vehicles that would fail an ASM at the Decision Point shown in the table is the number of vehicles that would fail at high-performing stations incremental to the number that would have failed at average-performing stations.

	Strategy	
Basic Ranking Method	Calling-In No-Sticker, Directing, Exempting	Scrapping
[a] Model Year	= FprobDP by A	= FprobDP/$ by A
[b] Vehicle Description	= FprobDP by B	= FprobDP/$ by B
[c] VID History	= ΔFMD by C	= ΔFTP CO/$ by C
[d] VID/RSD	= ΔFMD by D	= ΔFTP CO/$ by D
[f] RSD	= FprobDP by F	= FprobDP/$ by F

The first RSD ranking method (in the fourth column), which uses only RSD measurements can cover only 17% of the statewide I/M fleet. With this method, the remaining 83% of the fleet cannot participate in special strategies. The costs for this method are dominated by the $63 million spent for collecting RSD measurements in the five major AQMDs in the state. As a consequence of the 17% statewide I/M fleet coverage, non-RSD costs are relatively low in comparison since a relatively low number of vehicles can participate in the strategies. In total, the RSD-alone ranking method has biennial costs of about $86 million.

The second and third RSD ranking methods (in the fifth and sixth columns) supplement the RSD-containing ranking methods, which can cover only 17% of the statewide I/M fleet, with the VID History method so that the entire statewide I/M fleet can be covered with some ranking method. For each of these two "hybrid" methods, the costs are dominated by a large savings of $83 million associated with the exemption of 20% of the fleet for one biennial inspection. In addition, large expenditures are made for Calling-In inspections, Calling-In repairs, Directing repairs, and Scrapping vehicle purchases. However, these two methods also have $63 million in RSD data collection costs that the non-RSD ranking methods (in the first three columns) do not have. In total, the two hybrid RSD ranking methods have biennial costs of about $97 million.

Benefits – The total benefits from the four strategies are based on the basic ranking methods described in Reference 1 and on the selected penetration rates. The benefits are scaled to the California fleet using EMFAC projections described in Section 4.

The total emissions benefits of 10,461 tons/2years are largest for the best RSD full-fleet ranking method (VID/RSD + VID History), while the best non-RSD full-fleet ranking method (VID History) results in emissions benefits of 10,053 tons/2years – almost as large. Thus, the incremental benefits of the best RSD model over the best non-RSD model are about 408 tons/2years, which is about 0.07% of the I/M fleet biennial emissions inventory, but those incremental benefits come at a significantly higher cost – $64,838,889 more.

For the non-RSD ranking methods (in the first three columns) the VID History method has the highest benefits, and the Vehicle Description method, which is most similar to the current HEP, has the lowest benefits. Except for its Calling-In performance, the Model Year method[7] has a benefit performance that is nearly as high as that of the VID History method.

[7] The Model Year method does not simply select vehicles based on their model years. For Directing, Exempting, and Calling-In, vehicles are ranked by the ASM Fprob that is associated with the model year. For Scrapping, vehicles are ranked by the ASM Fprob that is associated with the model year divided by the value of the vehicle. See the modeling report [1].

Of the two hybrid RSD ranking methods (in the fifth and sixth columns), the VID/RSD + VID History method (sixth column) has slightly better benefits performance than the RSD + VID History method (fifth column). The improved performance is made at virtually the same cost by using VID information to help the RSD measurements on the 17% of the I/M fleet that RSD covers.

Of all of the ranking methods, the RSD-alone method (fourth column) has the poorest performance. At 2,793 tons/2years, the RSD-alone method reduces emissions by about half as much as the next worst method, the Vehicle Description method, which is similar to the current HEP. And it reduces emissions by only about 27% as much as the best method, the VID/RSD + VID History method.

Cost-Effectiveness – The cost-effectivenesses of the non-RSD ranking methods for the four strategy package at the chosen penetrations are between $3,200/ton and $6,400/ton. The VID History method has the best cost-effectiveness of all six of the ranking methods at $3,243/ton. The cost-effectivenesses of the RSD ranking methods for the four strategy package at the chosen penetrations are between $9,300/ton and $30,800/ton. The best RSD method, VID/RSD + VID History, has the best cost-effectiveness of the three RSD-containing ranking methods at $9,314/ton. On the surface this cost-effectiveness figure looks attractive until one considers how much the RSD information contributes to the cost-effectiveness. The VID/RSD + VID History method gets a benefit of only 408 tons/2years but $63 million in increased cost from the RSD measurement portion of that method. On the other hand, the VID/RSD + VID History method gets 96% (= 10,053 tons / 10,461 tons) of the benefit but only 33% (= $32,599,772 / $97,438,659) of the expense from the VID information. The bottom line for this analysis is that the incremental cost-effectiveness for RSD is $158,877/ton. This cost-effectiveness has been developed for the selected penetration rates for the four intervention activities considered.

In addition, the incremental changes in failed miles driven are presented in Table 6-1. The best RSD model (VID/RSD + VID History) achieves the largest reduction in failed miles driven based on the selected intervention activities, but the reduction for the best non-RSD model (VID History) is almost as large. The incremental reduction in failed miles driven by the best RSD model over the best non-RSD model is only 0.2% of the failed miles driven by the I/M fleet.

Table 6-1 also shows the number of vehicles targeted, the number of targeted vehicles that would fail an ASM at the Decision Point, and the corresponding fraction of targeted vehicles that would fail at the Decision Point. For Calling-In, the fail fractions are between 29% and 44%. This is substantially higher than the overall I/M program ASM failure rate of 10.2% (see Table 4-1). This demonstrates the effectiveness of vehicle ranking. The highest fail fraction for the Calling-In ASM of 44% is provided by the RSD-alone ranking method (in the fourth column), but this level is not close to the desired fail rate of 95%. The fail fractions of Scrapping targets provide similar results. Again, the highest fail fraction of 45% for the scrappage ASM test is provided by the RSD-alone ranking method. However, Table 6-1 also shows that while the RSD-alone method provides the highest, although insufficiently high, fail fractions, the benefits of the RSD-alone method are the lowest – by far – of all of the vehicle ranking methods for Calling-In and Scrapping. This is a consequence of RSD's inability to cover a large fraction of the I/M fleet with usable-VSP RSD measurements.

In the case of Directing, the table shows the incremental counts and fraction of targeted vehicles that would be directed to high-performing stations rather than be allowed to get their regularly scheduled inspections at average-performing stations. All six of the ranking methods have an increase in fail fractions of about 2% of the targeted vehicles; however, because the RSD-alone method can target only 17% of the statewide I/M fleet, the number of vehicles that can be targeted by RSD-alone and that would fail at the high-performing stations is the lowest at 23,107. This is one-fifth of the next lowest competitor. The table also shows that the number of tons of HC + NX emissions reduced by Directing with RSD-alone is far lower at 730 tons/2years than all other competitors.

In the case of Exempting, Table 6-1 shows the number and fraction of the vehicles targeted for Exempting that would have failed if they had not been exempted. The RSD-alone results show that only 0.9% would have failed, but the Vehicle Description method (in the second column) has a slightly better (i.e., lower) result. And, as for Directing, because RSD can cover only 17% of the statewide I/M fleet with usable RSD measurements, the 454,323 vehicles exempted by RSD-alone is much lower than for the other Exempting ranking methods.

The last line of Table 6-1 shows the average vehicle value of the vehicles that are targeted for Scrapping. This quantity is useful to help determine the size of the scrappage offers that might be accepted by potential scrappage vehicle owners. Obviously, owners will not be very likely to accept a state's offer that is below the value of the vehicle. For the Scrapping scenario calculated in Table 6-1, five of the ranking methods selected vehicles for Scrapping that had average values between \$600 and \$700. But RSD-alone selected vehicles with an average value of \$1,053. Again, this is caused by low usable-VSP RSD coverage of the statewide I/M fleet. This in turn caused a larger Scrapping penetration of 1.4% that was needed to spend the

$16 million Scrapping vehicle purchase budget. Larger penetration means that vehicle selection had to cut deeper into the portion of the fleet that had RSD measurements. This caused vehicles with higher values to be selected.

6.2 Performance of the Three-Strategy Package

For this report, we also performed a cost, benefit, and cost-effectiveness analysis for a package of three strategies. We examined Directing, Exempting, and Scrapping at the same penetrations used in the analysis in Section 6.1. We left Calling-In out of the package because through an examination of many cost-effectiveness calculation runs, we saw that Calling-In was not cost-effective in comparison with the other three strategies. For example, for the VID History ranking method, we found the following cost-effectivenesses when each of the three emissions-reducing strategies was used alone: $15,870/ton for Calling-In, $5,943/ton for Directing, and $5,385/ton for Scrapping. In addition, we had heard from other jurisdictions that when Calling-In was attempted, few motorists responded to the call-in emissions test request.

Table 6-2 shows the results of the analysis on the three-strategy package. By comparing Figure 6-2 with Figure 6-1, we can see that leaving out Calling-In reduced central office costs, Calling-In notices, Calling-In inspections, and Calling-In repairs. This reduced the costs by about $70 million for the five non-RSD-alone ranking methods and reduced costs by about $14 million for the RSD-alone method (in the fourth column). Of course, the benefits of Calling-In were reduced to zero. The reductions in total benefits associated with dropping the Calling-In strategy were from 1,800 tons/2years to 4,700 tons/2years depending on the ranking method.

Table 6-2 shows the result of dropping the Calling-In strategy as a substantial improvement in cost-effectiveness for the package. Now, the non-RSD ranking methods show an overall <u>savings</u> of $37 million while at the same time reducing emissions by 3,500 tons/2years to 5,400 tons/2years. The RSD-containing ranking methods are also far less expensive and therefore more cost-effective. Nevertheless, the table shows that the incremental benefits and cost-effectiveness of adding RSD is still quite cost-ineffective at $228,563/ton.

Table 6-2. Cost-Effectiveness Summary for Directing, Exempting, Scrapping

	Full-Fleet Ranking Method						
	Model Year [a]	Vehicle Description [b]	VID History [c]	RSD [f] 16.97% of statewide I/M fleet	RSD [f] 16.97% of statewide I/M fleet	VID/RSD [d] 16.97% of statewide I/M fleet	Incremental Benefit of VID/RSD + VID History over VID History
	100% of statewide I/M fleet	100% of statewide I/M fleet	100% of statewide I/M fleet	Nothing 83.03% of statewide I/M fleet	VID History [c] 83.03% of statewide I/M fleet	VID History [c] 83.03% of statewide I/M fleet	
	without RSD			with RSD			
Cost Items ($/2years) [A]							
Central Office	$3,060,165	$3,060,165	$3,060,165	$3,032,944	$3,354,019	$3,354,019	$293,854
0% Calling-In No-Sticker							
40% Directing							
20% Exempting							
Scrapping							
RSD Measurements	$0	$0	$0	$63,276,265	$63,276,265	$63,276,265	$63,276,265
0% Calling-In No-Sticker							
40% Directing							
20% Exempting							
Scrapping							
Notice							
0% Calling-In No-Sticker	$0	$0	$0	$0	$0	$0	$0
40% Directing	$0	$0	$0	$0	$0	$0	$0
20% Exempting	$0	$0	$0	$0	$0	$0	$0
Scrapping	$249,018	$192,788	$176,723	$95,408	$172,706	$168,690	($8,033)
Inspection							
0% Calling-In No-Sticker	$0	$0	$0	$0	$0	$0	$0
40% Directing	$0	$0	$0	$0	$0	$0	$0
20% Exempting	($83,006,028)	($83,006,028)	($83,006,028)	($14,084,001)	($83,006,028)	($83,006,028)	$0
Scrapping	$4,150,301	$3,213,137	$2,945,375	$1,590,129	$2,878,435	$2,811,494	($133,881)
Certificate							
0% Calling-In No-Sticker	$0	$0	$0	$0	$0	$0	$0
40% Directing	$0	$0	$0	$0	$0	$0	$0
20% Exempting	$0	$0	$0	$0	$0	$0	$0
Scrapping	($216,004)	($195,610)	($189,220)	($118,670)	($190,105)	($188,261)	$959
Repair							
0% Calling-In No-Sticker	$0	$0	$0	$0	$0	$0	$0
40% Directing	$24,392,479	$25,956,630	$22,325,603	$4,482,830	$23,020,348	$22,939,542	$613,939
20% Exempting	$2,430,309	$1,434,738	$5,095,806	$345,963	$4,577,141	$4,725,082	($370,724)
Scrapping	($3,809,524)	($3,449,857)	($3,337,149)	($2,092,905)	($3,352,768)	($3,320,241)	$16,908
Vehicle Purchase							
Fleet Sample Penetration (%)	**0.620**	**0.480**	**0.440**	**1.400**	**0.430**	**0.420**	
Scrapping	$15,642,628	$15,624,309	$15,672,716	$15,142,381	$15,667,580	$15,774,574	$101,858
Model Update & Maintenance	$0	$400,000	$400,000	$400,000	$400,000	$400,000	$0
0% Calling-In No-Sticker							
40% Directing							
20% Exempting							
Scrapping							
Total Costs ($/2years) [A]	($37,106,502)	($36,769,589)	($36,855,875)	$72,070,538	$26,797,726	$26,935,269	$63,791,145
ΔFTP (HC+NX tons/2years) out of 605088 total tons/2years							
0% Calling-In No-Sticker	0	0	0	0	0	0	0
40% Directing	(3,876)	(3,897)	(4,339)	(730)	(4,333)	(4,423)	(84)
20% Exempting	3,241	3,942	2,358	529	2,487	2,212	(146)
Scrapping	(3,997)	(3,533)	(3,478)	(2,034)	(3,553)	(3,527)	(49)
Total ΔFTP (HC+NX tons/2years) [B]	(4,632)	(3,488)	(5,459)	(2,236)	(5,400)	(5,738)	**(279)**
Cost Effectiveness ($/ton HC+NX) [C]	8,011	10,541	6,752	(32,235)	(4,963)	(4,694)	**(228,563)**
ΔFMD (miles/2years) out of 30624179635 total FMD/2years							
0% Calling-In No-Sticker	0	0	0	0	0	0	0
40% Directing	(486,496,190)	(538,672,116)	(594,758,300)	(96,525,257)	(590,368,275)	(606,709,974)	(11,951,674)
20% Exempting	200,602,866	133,453,029	143,777,037	26,921,267	146,303,015	122,609,996	(21,167,040)
Scrapping	(179,679,066)	(186,801,268)	(190,210,114)	(133,180,660)	(192,713,478)	(194,587,521)	(4,377,407)
Total ΔFMD (miles/2years) [D]	(465,572,391)	(592,020,355)	(641,191,378)	(202,784,650)	(636,778,739)	(678,687,499)	(37,496,121)

Table 6-2 (Continued)

	Full-Fleet Ranking Method						
	without RSD			with RSD			
	Model Year [a] 100% of statewide I/M fleet	Vehicle Description [b] 100% of statewide I/M fleet	VID History [c] 100% of statewide I/M fleet	RSD [f] 16.97% of statewide I/M fleet; Nothing 83.03% of statewide I/M fleet	RSD [f] 16.97% of statewide I/M fleet; VID History [c] 83.03% of statewide I/M fleet	VID/RSD [d] 16.97% of statewide I/M fleet; VID History [c] 83.03% of statewide I/M fleet	Incremental Benefit of VID/RSD + VID History over VID History
Total Number of Targeted Vehicles							
0% Calling-In No-Sticker	0	0	0	0	0	0	0
40% Directing	5,355,228	5,355,228	5,355,228	908,645	5,355,228	5,355,228	0
20% Exempting	2,677,614	2,677,614	2,677,614	454,323	2,677,614	2,677,614	0
Scrapping	83,006	64,263	58,908	31,803	57,569	56,230	(2,678)
Targeted Vehicles That Would Fail an ASM at the Decision Point							
0% Calling-In No-Sticker	0	0	0	0	0	0	0
40% Directing [E]	125,734	133,797	115,080	23,107	118,662	118,245	3,165
20% Exempting	27,839	16,435	58,371	3,963	52,430	54,125	(4,247)
Scrapping	26,182	23,710	22,936	14,384	23,043	22,820	(116)
Fraction of Targeted Vehicles That Would Fail an ASM at the Decision Point							
0% Calling-In No-Sticker	N/A	N/A	N/A	N/A	N/A	N/A	
40% Directing [E]	0.023	0.025	0.021	0.025	0.022	0.022	
20% Exempting	0.010	0.006	0.022	0.009	0.020	0.020	
Scrapping	0.32	0.37	0.39	0.45	0.40	0.41	
Average Value of Vehicles Targeted for Scrapping	$597	$659	$683	$1,053	$680	$691	

Footnotes

[A] Negative Costs means saving money, Positive Costs means spending money.
[B] Negative ΔFTP means emissions decrease, Positive ΔFTP means emissions increase.
[C] Interpret cost effectiveness value in terms of Total Costs and Total ΔFTP.
[D] Negative ΔFMD means decrease in total Failed Miles Driven, Positive ΔFMD means increase in total Failed Miles Driven.
[E] The number of directed vehicles that would fail an ASM at the Decision Point shown in the table is the number of vehicles that would fail at high-performing stations incremental to the number that would have failed at average-performing stations.

	Strategy	
Basic Ranking Method	Calling-In No-Sticker, Directing, Exempting	Scrapping
[a] Model Year	= FprobDP by A	= FprobDP/$ by A
[b] Vehicle Description	= FprobDP by B	= FprobDP/$ by B
[c] VID History	= ΔFMD by C	= ΔFTP CO/$ by C
[d] VID/RSD	= ΔFMD by D	= ΔFTP CO/$ by D
[f] RSD	= FprobDP by F	= FprobDP/$ by F

7.0 References

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Appendix A

Summary of Selected RSD Coverage Scenarios

Table A-1. RSD Measurement Counts for the Large RSD Program (Any-VSP RSD Coverage = 50%) (Usable-VSP RSD Coverage = 20%)

Area	Subject to I/M, In-range-VSP, Unique, Valid, DMV-Matched	In-range-VSP, Unique, Valid, DMV-Matched	Unique, Valid, DMV-Matched	Valid, DMV-Matched	Valid	Raw
	60% of In-range VSP, Unique, Valid, DMV-Matched	40% of Unique, Valid, DMV-Matched	30.0% of Valid, DMV-Matched	60% of Valid	75% of Raw	
Sacramento	98,820	165,158	412,896	1,376,320	2,293,866	3,058,489
San Diego	235,342	393,330	983,325	3,277,748	5,462,914	7,283,885
San Joaquin	246,148	411,391	1,028,477	3,428,257	5,713,762	7,618,350
South Coast	1,089,056	1,820,154	4,550,384	15,167,948	25,279,913	33,706,551
Bay Area	557,136	931,148	2,327,870	7,759,568	12,932,613	17,243,484
Rest of State	45,111	75,395	188,487	628,291	1,047,151	1,396,202
Total	2,271,613	3,796,576[c]	9,491,440[b]	31,638,132[a]	52,730,220	70,306,961

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[a]Used to determine RSD data collection cost. Estimated RSD data collection cost is $1.00/valid, DMV-matched RSD reading for a total annual RSD data collection cost of $31,638,132.
[b]Used to determine the Any-VSP RSD Coverage of the (I/M + non-I/M) fleet driving in the five largest AQMDs.
[c]Used to determine the Usable-VSP RSD Coverage of the (I/M + non-I/M) fleet driving in the five largest AQMDs.

Table A-2. RSD Measurement Counts for the Medium RSD Program (Any-VSP RSD Coverage = 30%) (Usable-VSP RSD Coverage = 12%)

Area	Subject to I/M, In-range-VSP, Unique, Valid, DMV-Matched	In-range-VSP, Unique, Valid, DMV-Matched	Unique, Valid, DMV-Matched	Valid, DMV-Matched	Valid	Raw
	60% of In-range VSP, Unique, Valid, DMV-Matched	40% of Unique, Valid, DMV-Matched	34.0% of Valid, DMV-Matched	60% of Valid	75% of Raw	
Sacramento	59,292	99,095	247,738	728,640	1,214,400	1,619,200
San Diego	141,205	235,998	589,995	1,735,279	2,892,131	3,856,175
San Joaquin	147,689	246,835	617,086	1,814,960	3,024,933	4,033,244
South Coast	653,434	1,092,092	2,730,231	8,030,090	13,383,484	17,844,645
Bay Area	334,281	558,689	1,396,722	4,108,006	6,846,677	9,128,903
Rest of State	27,067	45,237	113,092	332,625	554,374	739,166
Total	1,362,968	2,277,946[c]	5,694,864[b]	16,749,599[a]	27,915,999	37,221,332

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[a]Used to determine RSD data collection cost. Estimated RSD data collection cost is $0.69/valid, DMV-matched RSD reading for a total annual RSD data collection cost of $11,485,402.
[b]Used to determine the Any-VSP RSD Coverage of the (I/M + non-I/M) fleet driving in the five largest AQMDs.
[c]Used to determine the Usable-VSP RSD Coverage of the (I/M + non-I/M) fleet driving in the five largest AQMDs.

Table A-3. RSD Measurement Counts for the Small RSD Program
(Any-VSP RSD Coverage = 10%)
(Usable-VSP RSD Coverage = 4%)

Area	**Subject to I/M, In-range-VSP, Unique, Valid, DMV-Matched**	**In-range-VSP, Unique, Valid, DMV-Matched**	**Unique, Valid, DMV-Matched**	**Valid, DMV-Matched**	**Valid**	**Raw**
	60% of In-range VSP, Unique, Valid, DMV-Matched	40% of Unique, Valid, DMV-Matched	38.0% of Valid, DMV-Matched	60% of Valid	75% of Raw	
Sacramento	19,764	33,032	82,579	217,314	362,189	482,919
San Diego	47,068	78,666	196,665	517,539	862,565	1,150,087
San Joaquin	49,230	82,278	205,695	541,304	902,173	1,202,897
South Coast	217,811	364,031	910,077	2,394,939	3,991,565	5,322,087
Bay Area	111,427	186,230	465,574	1,225,195	2,041,992	2,722,655
Rest of State	9,022	15,079	37,697	99,204	165,340	220,453
Total	454,323	759,315[c]	1,898,288[b]	4,995,495[a]	8,325,824	11,101,099

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[a]Used to determine RSD data collection cost. Estimated RSD data collection cost is $0.52/valid, DMV-matched RSD reading for a total annual RSD data collection cost of $2,616,680.
[b]Used to determine the Any-VSP RSD Coverage of the (I/M + non-I/M) fleet driving in the five largest AQMDs.
[c]Used to determine the Usable-VSP RSD Coverage of the (I/M + non-I/M) fleet driving in the five largest AQMDs.

Table A-4. RSD Measurement Counts for the Fleet-Characterization RSD Program (Any-VSP RSD Coverage = 10 %) (Usable-VSP RSD Coverage = 4 %)

Area	Subject to I/M, In-range-VSP, Unique, Valid, DMV-Matched	In-range-VSP, Unique, Valid, DMV-Matched	Unique, Valid, DMV-Matched	Valid, DMV-Matched	Valid	Raw
	60% of In-range VSP, Unique, Valid, DMV-Matched	40% of Unique, Valid, DMV-Matched	36.5% of Valid, DMV-Matched	60% of Valid	75% of Raw	
Sacramento	77,079	128,824	322,059	1,000,183[a]	1,666,971	2,222,628
San Diego	87,076	145,532	363,830	1,002,287[a]	1,670,478	2,227,304
San Joaquin	87,383	146,044	365,109	1,001,672[a]	1,669,453	2,225,938
South Coast	92,570	154,713	386,783	987,951[a]	1,646,584	2,195,446
Bay Area	91,927	153,639	384,099	1,001,561[a]	1,669,268	2,225,691
Rest of State						
Total	436,035	728,752[c]	1,821,880[b]	4,993,653	8,322,755	11,097,006

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[a]Used to determine RSD data collection cost. As shown in the table below, because the Any-VSP RSD Coverage is different in the different areas for this RSD data collection program, the RSD unit cost varies by area. The table shows that with this RSD measurement program the net effective RSD unit cost would be about $0.60/valid, DMV-matched RSD reading for a total annual RSD data collection cost of $2,977,071.

Area	Any-VSP RSD Coverage Required (%)	Number of Valid, DMV-Matched RSD Readings	RSD Measurement Unit Cost ($/valid, DMV-matched RSD reading)	RSD Measurement Cost ($)
Sacramento	39.00	1,000,183	0.81	810,148
San Diego	18.50	1,002,287	0.57	571,303
San Joaquin	17.75	1,001,672	0.57	570,953
South Coast	4.25	987,951	0.51	503,855
Bay Area	8.25	1,001,561	0.52	520,812
Total		4,993,653		2,977,071

[b]Used to determine the Any-VSP RSD Coverage of the (I/M + non-I/M) fleet driving in the five largest AQMDs.
[c]Used to determine the Usable-VSP RSD Coverage of the (I/M + non-I/M) fleet driving in the five largest AQMDs.

Appendix B

The Rate at which RSD Measurements Produce Valid, Matched, Unique Vehicles within a Given Operating Range

This appendix discusses the evidence behind assumptions of how many of the vehicles passing an RSD measurement unit will produce a valid RSD measurement on a vehicle with a readable license plate image that is contained in the DMV registration database.

Issues involved in getting a usable RSD reading depend upon the intended use of the measurement. In the case of calling vehicles in for an off-cycle I/M inspection, the strictest of criteria must be used – those that will minimize the chance that the vehicle will be called in unfairly. Here is a list of issues that affect the usability of an RSD measurement.

1. Not all vehicles that drive past an RSD unit receive a valid measurement. For example, many vehicles that are coasting do not have enough of an exhaust plume to be measured accurately, so the RSD software rejects the measurement.

2. Not all valid measurements are accompanied by a usable license plate image. For example, sometimes glare or dirt obscures the plate image or the vehicle is from out of state or it has a temporary "paper" license plate because it was recently sold.

3. How long an RSD unit spends at each site affects how much of the fleet it has a chance to get a measurement on. If the RSD units are moved frequently, they will get measurements on more of the fleet than if they spend their time at only a few sites. Also, redundant measurements (repeated on the same vehicle) are valuable for some uses, but there is a limit to how many actually add useful information.

4. Sometimes vehicles are driven past an RSD unit in a way that does not fairly represent whether that vehicle is a high emitter or not. At some point in practically every trip a vehicle takes, it will be operated in a way that does not fairly represent the vehicle. Since vehicles are certified to their pollution standards in a very controlled situation, it is normal for even the cleanest of vehicles to emit short puffs of pollution under extreme operating conditions (e.g., a very hard acceleration). If RSD data is to be used to call in vehicles for off-cycle inspection, it must be evaluated in a way that minimizes the incidence of such unfair measurements.

Below, we describe how we have accounted for these four issues in the assumptions of the size of the required RSD programs.

What fraction of vehicles driving past an RSD unit receive a valid measurement?

We can estimate this fraction from empirical evidence. Data from the California Pilot RSD project are most applicable, but many other programs and research projects are also applicable.

During the pilot project, valid fractions ranged from almost zero to nearly 98% for freeway ramp sites, and from zero to 92% for surface street sites. These huge ranges are acceptable for a research project, but not for an actual RSD program. In actual RSD programs, sites that do not produce valid fractions of above 60% are not generally considered productive enough. The average percentage of valid readings in RSD programs ranges from 75% to 90%. We have assumed an average for California programs of 75%.

What fraction of vehicles driving past an RSD unit record a usable license plate image?

For many reasons, not all vehicles driving past an RSD unit get a usable image of their license plate recorded. For example, trailer hitches, glare from the sun, and shadows can make the plates unreadable. Also, a number of other circumstances make the plate images unusable. For example, many vehicles drive with "paper" plates from the car dealer or have plates from out of state.

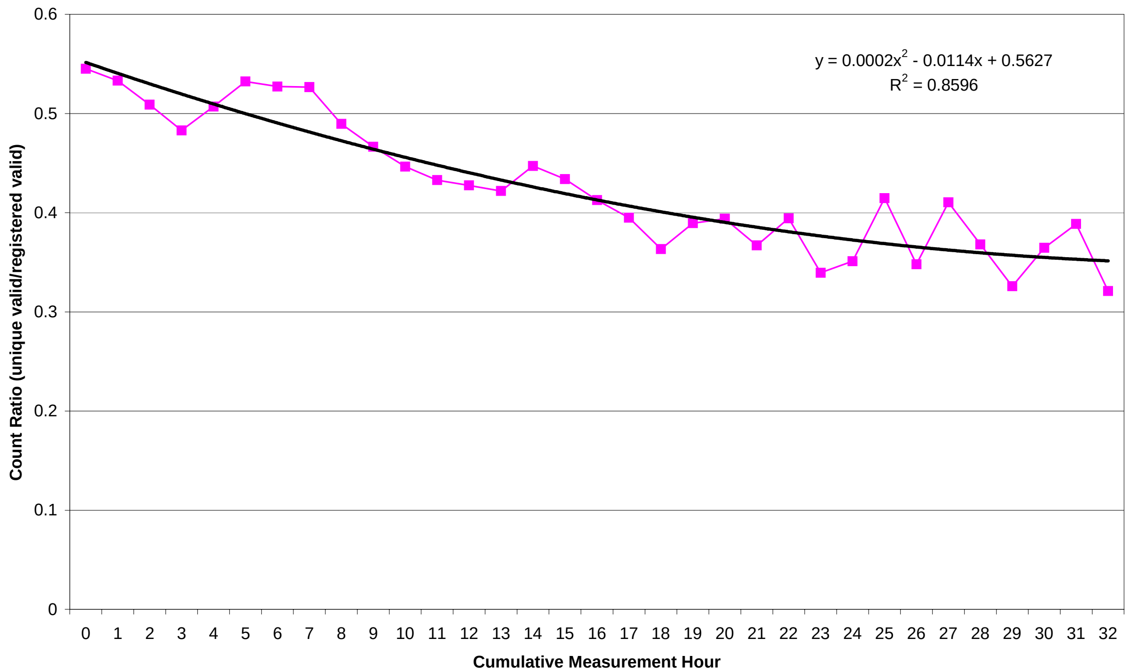
Experience from this pilot RSD program has shown that about 60% of the license plate images are useful. This is similar to experience from other RSD programs.

What fraction of vehicles driving past an RSD unit are unique (not redundant) measurements?

Usually called "fleet coverage," this is the fraction of the fleet measured at least once by RSD. To maximize fleet coverage, RSD units should visit as many sites as possible. Vehicles tend to be driven in the same area, so if an RSD unit stays at one site too long, it will eventually be measuring mostly the same vehicles over and over. So when an RSD unit first visits a site, most of the vehicles will be getting their first RSD measurements, but after only a few days, the productivity of the site falls because the same vehicles are passing the RSD unit day after day.

The productivity curve (the percentage of vehicles receiving their first RSD measurement of the RSD Pilot Project) of a typical site in Sacramento is shown in Figure B-1. Within 8-hours of testing at one site, the productivity falls (on average) from about 55% of the vehicles receiving their first RSD measurement, to about 48%. Within 32 hours the average productivity falls to around 35%. This result is consistent with observations from other programs, where sites are changed frequently enough to keep productivity averages around 40%.

Figure B-1. The Average Unique-Vehicle Productivity of Sacramento Sites in the Pilot RSD Program



What is a "fair" driving mode range, and what fraction of vehicles driving past an RSD unit are driving in that range?

There is a range of driving modes that represent the driving conditions under which vehicles are tested to find out if they emit too much pollution. For this reason, vehicle driving conditions must be monitored while measuring emissions, so vehicles are not unfairly labeled as "high-emitters." (All vehicles can have high emissions under some driving conditions, like a high acceleration or driving up a steep hill.)

RSD takes a snap-shot measurement (less than one-second) of a vehicle's exhaust. Much like a photographic portrait taken while the subject is blinking, an RSD measurement may not be a fair representation of the vehicle's normal condition unless it is carefully taken and analyzed. Site selection is a critically important part of collecting representative vehicle RSD data. The site can help limit vehicle operating conditions to a "representative" mode. Unfortunately, RSD sites that both provide ample traffic volume and representative conditions are not plentiful. Post-processing and analysis of the data are also critical. Researchers use quality assurance techniques and "filter" the speed and acceleration measurements to try to determine which vehicles were "blinking" (i.e., in an unrepresentative operating mode) at the time of the measurement.

In RSD measurements the vehicle operating range is characterized using a calculated value to estimate the load on a vehicle's engine. The value is called Vehicle Specific Power or VSP. It is typically expressed in units of kilowatts per metric ton or kW/Mg.

In previous RSD studies various ranges of VSP have been used, with that of 5 kW/Mg to 20 kW/Mg being the most prevalent lately, since it is approximately the range of engine loads found in the federal and California tests used to certify that new vehicles are as clean as they should be. When choosing the range of VSPs to accept for usable RSD measurements, there is a trade-off between emissions-representativeness and quantity of usable RSD measurements. In this study, we chose to use RSD measurements that have a VSP range of 5 to 25 kW/Mg. For all sites in Sacramento, about 44% of the vehicles drove past RSD sites in this VSP range.